Health and Disease in Byzantine Crete (7th–12th centuries AD)

Chryssi Bourbou

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HEALTH AND DISEASE IN BYZANTINE CRETE (7TH–12TH CENTURIES AD)

Daily life and living conditions in the Byzantine world are relatively underexplored subjects, often neglected in comparison with more visible aspects of Byzantine culture, such as works of art. The book is among the few publications on Greek Byzantine populations and helps pioneer a new approach to the subject, opening a window on health status and dietary patterns through the lens of bioarchaeological research. Drawing on a diversity of disciplines (biology, chemistry, archaeology and history), the author focuses on the complex interaction between physiology, culture and the environment in Byzantine populations from Crete in the 7th to 12th centuries.

The systematic analysis and interpretation of the mortality profiles, the observed pathological conditions, and of the chemical data, all set in the cultural context of the era, brings new evidence to bear on the reconstruction of living conditions in Byzantine Crete. Individual chapters look at the demographic profiles and mortality patterns of adult and non-adult populations, and study dietary habits and breastfeeding and weaning patterns. In addition, this book provides an indispensable body of primary data for future research in these fields, and so furthers an interdisciplinary approach in tracing the health of the past populations.

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To Dionysis and my family with love

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Foreword

Careful excavation and research on archaeological human skeletons provide insight into important aspects of the lives of our ancestors that is not accessible through any other source. Like our older living relatives, archaeological human burials have much to teach us through the information we can gain through analysis of data from these remains. However, there are challenges in achieving this objective. Increasingly archaeologists are recognizing the value of biological data in reconstructing the culture of past human societies. Similarly biological anthropologists recognize that data from human remains are affected by the culture represented by human skeletal samples. This reality has promoted cooperation and collaboration between an archaeologist excavating a site and the biological anthropologist analyzing the human burials that may be recovered from the site – ideally with active involvement of the biological anthropologist during excavation. This emphasis on the need to integrate cultural and biological data in the interpretation of skeletal data has led to the use of the term bioarchaeology to describe a research emphasis in which archaeology provides an important context for interpreting the data extracted from archaeological human remains. Dr Chryssi Bourbou's book provides a commendable example of this emphasis in which she provides the archaeological context for the skeletal remains which are the main focus of her book and utilizes this context in interpreting the results of her analysis.

The remarkable improvements I have witnessed during my lifetime in both the quality and quantity of data that can be obtained from comprehensive skeletal analysis highlights the fact that current scientific methods, if rigorously applied, provide the pathway to a more complete understanding of our past and our relationship to those who have lived before us. It also emphasizes the fact that new methods are likely to be developed in the future and that long-term storage and curation of archaeological skeletal samples is highly likely to provide a source of important new data in the future.

In the following pages, Bourbou has provided the reader with a careful analysis and interpretation of human remains dated to the Byzantine Period (seventh to twelfth centuries AD) and excavated from archaeological sites on the island of Crete in Greece. In her research she has demonstrated again the value of data obtained through the study of human remains. My late mentor and colleague, Dr J. Lawrence Angel, had done remarkable pioneer research on human skeletal biology in the eastern Mediterranean with an emphasis on Greece from the Neolithic Period through the Greek Classical Period. As Bourbou notes, Angel was one of the early scientists to attempt the linkage between the cultural and biological environment with the evidence of the human biological adjustment to this environment provided through analysis of the skeleton. Bourbou has applied more recent bioarchaeological methodology to highlight a phase in Greek history that has not received the attention from which earlier periods have benefited.

The analytical methods available today provide tools that I could not even imagine early in my career. Refinements in dating methods permit much greater accuracy in determining the archaeological age of human remains and radiocarbon dating using accelerator mass spectrometry requires much smaller samples than earlier dating methods. Furthermore we are much more aware of the factors that can distort dating methods. Mass spectrometry has also made possible analysis of stable isotopes that provide data for reconstructing some aspects of the diet in human archaeological skeletal samples. This research methodology is tangibly demonstrated in Bourbou's interpretation of stable isotope data in Chapter 4 indicating a dietary emphasis on wheat, oil and wine.

Our knowledge about the skeletal disorders that one encounters in the study of human remains has increased dramatically during the 40 years I have been conducting research on human skeletal paleopathology. Ongoing research continues to improve and provide data on the health of past human populations. One of the developments has been a heightened understanding of the skeletal manifestations of two of the metabolic disorders, scurvy and rickets. My own research on scurvy provided the observations needed to identify this disorder in sub-adult skeletons. However, it also raised questions about the pathological significance of porous lesions in the skull. The porous and sometimes hypertrophic lesions apparent in the orbits and skull vault of some sub-adult skulls had been attributed by Angel to one of the genetic anemias. Since Angel's 1966 paper in *Science*, in which he coined the term 'porotic hyperostosis' for the porous, hypertrophic lesions of the skull, the additional possibility of iron deficiency anemia was added to the list of diagnostic options associated with skull porosity. The term porotic hyperostosis, which should mean abnormal, porous bone formation, has become virtually synonymous with anemia including porous lesions not associated with new bone formation.

However, porous lesions of the skull and lesions in which there is porous hypertrophic bone formation can be caused by several disorders, including anemia, scurvy, rickets, infection and cancer. Anemia can only be identified anatomically if there is evidence of marrow hyperplasia associated with porotic hyperostosis. Angel knew this and assumed that everyone else using the term would as well. However, this has not been the case, with the result that the porous and porous hypertrophic lesions of the skull have been attributed, in most published reports, to anemia with virtually no attention being paid to the presence or absence of marrow hyperplasia. Bourbou is aware of the problem and in her research has wisely insisted on a multifactorial interpretation of these lesions. What is certainly true is that porotic and porotic hypertrophic lesions are indicative of a disorder and this has value as long as it is not attributed to a specific disorder without further evidence of pathogenesis such as the location of the lesions or the presence of marrow hyperplasia.

There are troublesome problems that remain to be dealt with in interpreting data from human skeletal samples. A vigorous scientific debate continues regarding the representativeness of archaeological skeletal samples relative to the living population from which the sample came. Clearly skeletal samples are not fully representative of the living population even in ideal situations. What is less clear is just how significant this limitation is. However, at the very least, bioarchaeologists need to be aware of the potential biases inherent in archaeological skeletal samples and avoid drawing conclusions that are not justified because of the limitations associated with the sample they are studying. For example, Bourbou notes that in Classical Greece children were not full members of society until the age of three and below that age may have been treated differently in the burial tradition. Many of the diseases that affect the skeleton can occur in infants and young children. If these are missing from the skeletal sample, disease prevalence will be distorted. Males and females may be buried in different areas of a cemetery. If the entire cemetery is not excavated this could result in a ratio between males and females that does not represent the living population.

Interpreting the significance of skeletal disease involves variables which current research has little ability to control. Although there are exceptions, the disorders one usually encounters in an archaeological burial are rarely the cause of death and may have had minimal morbidity. Skeletons with no evidence of disorder may represent very healthy people but it is also possible, for example, that they represent people with a poor immune response to infection and who die quickly before the skeleton can be involved.

Despite the limitations in interpreting the data recovered from archaeological human remains, there is much that we can learn from the analysis and Bourbou's book provides a helpful example of the insight available from rigorous analysis of skeletal samples. As we define more carefully the biases in skeletal samples and achieve greater understanding of the disorders that affect the skeleton, the quality and the interpretation of our data will improve. With growing experience in skeletal analysis it is probable that methods will be developed that will permit researchers to control for at least some of the limitations that currently exist.

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Introduction

This book is about the analysis and interpretation of lifestyle and disease in Byzantine Crete through the study of human skeletal remains and the use of innovative techniques such as chemical analysis (stable isotopes) for the reconstruction of dietary, breastfeeding and weaning patterns. The interaction between humans and their environment is a millennia-long affair that has attracted increasing interest from archaeologists since the development of science-based multidisciplinary applications in the field. In the last decade, the term 'bioarchaeology' has been applied to the subfield that through a multidisciplinary approach focuses on the human biological component of the archaeological record and offers insights into the lifestyle, demography, disease patterns (palaeopathology) and diet of past populations.[1]

Major or minor, each adaptation to a continuously changing environment is potentially reflected in our bodies. Thus, without studying humans themselves we could only partially reconstruct life in the past. Bones and teeth, as well as mummified remains, serve as the primary source of evidence for anthropological and palaeopathological analysis, while iconography and documentary evidence supplement the study of diseases in the past. The methods most frequently applied to the study of human remains are macroscopic (visual) observation, radiology and computed tomography.[2] More sophisticated techniques are increasingly being employed, providing more accurate information, but also leading to higher costs and technical demands. The application of biomolecular techniques such as ancient DNA (aDNA) analysis[3] has proven particularly useful for recognizing diseases that only affect soft tissues, such as the Black

1 Larsen 1997; for the use of the term 'bioarchaeology' since its first application during the 1970s, see Buikstra 2006, xvii–xx.

2 For the use of palaeoradiology, see Chhem and Rülhi 2004; for examples of the application of computed tomography, see Chhem et al. 2004; Ryan and Milner 2006; Kuhn et al. 2007.

3 For the contribution of ancient DNA analysis to archaeology, see Brown 2000; for a thorough review on methods and applications, see Kaestle and Horsburgh 2002.

Death.[4] Research to date has concentrated mainly on tuberculosis[5] and leprosy,[6] although DNA from the causative organisms for diseases such as venereal syphilis,[7] malaria,[8] Spanish influenza[9] and typhoid fever[10] has also been extracted and amplified from archaeological material. Microscopic applications (for example, palaeohistology) have also presented exciting possibilities, providing detailed information to make or confirm specific diagnoses.[11] Also of increasing importance has been the application of chemical analysis (for example, stable isotope analysis) for looking at dietary patterns in order to better understand the quality and balance of foodstuffs and their effect on health[12] or migration patterns.[13]

Limitations (for example, not all pathological conditions produce lesions on dry bone) and pitfalls in bioarchaeology, as in every discipline, give rise to various problems inherent to the study of human remains recovered from archaeological contexts. In 1992, Wood et al. published a thought-provoking paper that brought these problems to the attention of researchers. Their observations were – and still are – shared by the majority of specialists working in bioarchaeology, skeletal biology and related disciplines, who recognize that from the soil to the laboratory, human remains are subject to a number of extrinsic and intrinsic factors that potentially complicate any attempt to reconstruct past lifestyle and disease patterns.[14] Much criticism has also stemmed from the argument that since the early 1980s, a lack of shared and combined research between archaeology and physical anthropology is noted. Goldstein pointed to the need for more science- and laboratory-oriented research on human remains, whereas today physical anthropologists ignore archaeological data, and bioarchaeology seems to be solely the study of human remains recovered from an archaeological context.[15] Although some of her arguments and concerns are valid and are

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4 See, e.g., Drancourt et al. 1998, 2004, 2007; Wiechmann and Grupe 2005.

5 See, e.g., Taylor 1996; Taylor et al. 1999; Nerlich et al. 1997; Gernaey et al. 1999; Haas et al. 2000; Mays, Fysh and Taylor 2002.

6 Taylor et al. 2000.

7 Kolman et al. 1999.

8 Taylor, Rutland and Molleson 1997.

9 Reid et al. 1999.

10 Using aDNA, Papagrigorakis et al. 2006 have diagnosed typhoid fever as the cause of the Athenian plague.

11 Pfeiffer 2000; Bell and Piper 2000; Schultz 2001.

12 See, e.g., Müldner and Richards 2005, 2007a; Richards, Fuller and Molleson 2006.

13 Katzenberg 2000.

14 Roberts and Cox 2003, 16–17; Wright and Yoder 2003, 43–7.

15 Goldstein 2006, 376–9.

partially explained by the different trajectories the two disciplines have followed during the years, it must be always remembered that it is actually the educational background of the researcher that weighs most heavily upon the type of analysis applied. In other words, for an archaeologist specializing in the study of human remains the integration of archaeological, cultural and biological data is unquestionable in every attempt to reconstruct past lives, especially within historic contexts. Nevertheless, the 'bioarchaeological approach' is recognized as an important tool of investigation and, although still burdened with several complex unresolved issues, it remains our best option to understand fully the ways of life and death in the past.

During the last quarter of the nineteenth and the first half of the twentieth centuries, the educational background in medicine and biology of researchers involved in the study of human remains in Greece influenced their interests, which centered on exhaustive measurements and indices of variations between and within populations.[16] The physical anthropologist J. Lawrence Angel (1915–86) was the first to exhibit an interest in the skeletal biology of the Eastern Mediterranean, with Greece being the major focus throughout his life.[17] Angel belongs to the group of researchers who were responsible for shifting the research interests of palaeopathology from a static concern with the history of disease to questions concerning the epidemiology of diseases and their relation to other biocultural factors. Apart from his many reports on skeletal material from a variety of archaeological sites in Greece,[18] Angel had a keen interest in a number of areas of physical anthropology, such as palaeodemography,[19] palaeopathology (with publications on thalassaemia and its relationship to malaria in the Mediterranean area),[20] trauma[21] and occupationally related pathology.[22]

In the years that followed, bioarchaeology in Greece demonstrated a shift from hesitant and sporadic case studies to population-based analysis on a wider regional and temporal level. Most of these studies initially focused on prehistoric or classical populations.[23] Laskaris, in his survey of Byzantine cemeteries

16 For a thorough discussion of early studies of biological anthropology in Greece, see Roberts et al. 2005, 38–9, and for the current state of play, see Buikstra and Lagia 2009.

17 For the contribution of J. Lawrence Angel and Angel's corpus of publications, see Roberts et al. 2005, 4–5, and 51–8.

18 Perhaps one of his most important publications was on the population of Lerna, where he successfully combined biological and cultural data; see Angel 1971.

19 Angel, 1968, 1969.

20 Angel, 1964a, 1966, 1967, 1977, 1978.

21 Angel, 1974.

22 Angel, 1964b, 1982.

23 See, e.g., Papathanasiou 2001; Triantaphyllou 2001; Lagia, forthcoming.

and scattered burials throughout Greece, lists 561 sites, out of which only a very small number have received a thorough study of their recovered human skeletal remains.[24] This lack of skeletal studies for Byzantine populations can be explained to a great extent by the fact that very few systematic excavations have been carried out on Byzantine cemeteries and most of the material has been retrieved from rescue excavations, where it is at best viewed as a time- and money-consuming issue. Under these circumstances most Byzantine burial grounds are hastily excavated, and the material recovered is poorly stored and far less available for study and publication. In addition, human remains from Christian burials excavated within churches often end up in a communal grave after a brief ceremony by the local priest. In other European countries, such as the United Kingdom, specific guidelines are published for the treatment of human remains excavated in Christian burial grounds.[25] However, such protocols do not currently exist in Greece, highlighting the need for public awareness of the scientific value of human skeletal remains.

It is only in recent years that an increased interest has been expressed in the study of populations dating to Byzantine and post-Byzantine periods, or of specific segments of these populations such as non-adults.[26] Besides these population studies, researchers are increasingly using stable isotope analysis for detecting dietary, breastfeeding and weaning patterns, surveying as well the abundant documentary evidence against which the biological data can be projected and compared.[27] The present study focuses on the reconstruction of health status and dietary patterns of early (fourth to ninth centuries AD) and middle (tenth to thirteenth centuries AD) Byzantine populations from Crete.[28] Human skeletal collections from the early Byzantine period date mainly to the sixth–seventh centuries AD, and from the middle Byzantine period to

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24 Laskaris 2000, 284–7.

25 Mays 2005.

26 Barnes, 2002; Bourbou 2001a, 2004; Tritsaroli 2006; Bourbou and Tsilipakou 2009.

27 Garvie-Lok 2001; Bourbou and Richards 2007; Bourbou 2008; Bourbou, Fuller and Richards 2008; Bourbou and Garvie-Lok 2009; Bourbou and Garvie-Lok forthcoming.

28 Besides publications on Byzantine populations from Crete, some work has been also conducted on populations from the mainland: Tritsaroli 2006, the Peloponnese: Bourbou 2004; Wesolowsky 1973, North Greece: Agelarakis and Agelarakis 1989; Bourbou 1996; Bourbou and Tsilipakou 2009; Georgakopoulou and Xirotiris 2009, Thasos: Buchet and Sodini 1984. For a thorough review of publications for early Byzantine populations in Greece, see Bourbou 2004, 31–9. Current research on Byzantine populations is being conducted by Dr P. Tritsaroli at the sites of Xironomi (Boeotia), Porto Rafti and Taxiarchis Kalyvion (Attica), P. Tritsaroli pers. comm. 2008, and by Dr S. Garvie-Lok at Isthmia and Kenchreai (the Peloponnese), S. Garvie-Lok pers. comm. 2008.

the eleventh–twelfth centuries AD. Little information has been available for Byzantine Crete, making the contribution of an interdisciplinary approach essential. Documentary and archaeological evidence gives sparse and scattered information, resulting in more questions than answers for the transitional and idiosyncratic character of the period in question.[29] The multiple and intensive stresses (including invasions and natural disasters such as earthquakes) suffered periodically throughout the Byzantine period highlight the need for caution in order to avoid simplistic generalizations about everyday life and the socio-economic and cultural activities of its populations. Nevertheless, in the past few years a growing interest can be noted in the rather neglected and largely unknown Byzantine Crete. The international conference *Creta Romana e Protobizantina* (Heraklion, 2000) represented a pioneering effort to bring together researchers from a variety of specializations in order to determine the effects of the complex phenomena observed during the gradual transformation from the ancient to the Byzantine world, and the resulting four-volume corpus of papers was published in 2004.[30] Added to these proceedings is the extensive publication of the results obtained from years of systematic excavation at the early Byzantine site of Eleutherna.[31] Piece by piece, the picture of Byzantine Crete is being roughly shaped and, although still much work remains to be done, a solid background exists upon which science-based research can be conducted.[32]

Since studies published on health in past populations vary in quality, data for inclusion in this book have been mainly derived from the work conducted by the author for the sites of Eleutherna, Kastella and Stylos. For comparison, published data for other Byzantine populations from Crete have been scrutinized and modified as appropriate in order to provide a more complete picture of the era in question; the publications that have proven helpful include those on the early Byzantine sites of Gortyn, Knossos and Kefali Pediados.[33] For the reconstruction of dietary patterns it was thought more useful to include all available data from sites outside Crete, in order to have a better idea of the Byzantine dietary profile and attitudes towards breastfeeding and weaning patterns.

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29 Tsougarakis 1988.

30 Atti del Congresso Internazionale Creta Roman e Protobizantina, 2004.

31 Prof. P. Themelis, who supervised the field seasons from 1986 through 2003, acted as the editor of four distinctive volumes devoted to the meticulous study of the archaeological finds of Eleutherna: Themelis 2000, 2004; Bourbou 2004; Yangaki 2005.

32 It must be noted that the *International Conference on Cretological Studies*, which takes place every five years, and the *Conference on the Archaeological Work in Crete*, established in 2008 and expected to occur every two years, are the major forums for presenting archaeological projects conducted on the island.

33 Gortyn: Mallegni 1988; Knossos: Musgrave 1976; Kefali Pediados: Zygouri 2005.

The book begins with a presentation on the general context of Byzantine Crete, in order to contextualize the biological data and the methodology used for the anthropological and palaeopathological analysis (Chapter 1). The next two chapters discuss the results obtained from the study of the adult (Chapter 2) and non-adult (Chapter 3) segments of the populations, respectively. These chapters present the demographic profile and mortality patterns of the populations, as well as the observed pathological conditions.

There are a number of broad categories of disease that most palaeopathologists consider when studying past populations, some of which are more common than others. In this book the major disease categories (dental, joint and infectious diseases, hematopoietic and metabolic disorders, as well as traumatic incidents) are the areas focused on, but where evidence exists for rarer conditions (such as neoplastic and congenital) they are also included. Notably pathological conditions are better viewed in their biocultural context. Thus, for example, in terms of periodic crises and culturally influenced practices, it is impossible to ignore the impact of impoverished conditions on the development of specific pathological conditions.

Chapter 4 is devoted to stable isotope analysis applied to the study of dietary habits, as well as of breastfeeding and weaning patterns. The results obtained from such an analysis are viewed within the specific cultural context of the era: for example, it is essential to determine the likely $\delta^{13}C$ and $\delta^{15}N$ values of some of the items mentioned in the sources and known to be included in the Byzantine diet. Furthermore, fasting rules targeting some key animal products in the diet, or restrictions applied according to gender, should be considered when reconstructing Byzantine diets. Similarly, since attitudes towards breastfeeding and weaning patterns are cited in the written sources, isotopic data can ideally be projected and compared against documentary evidence. As the effects of weaning have been associated with the development of specific pathological conditions, special attention is given to metabolic and hematopoietic disorders. Finally, a synthesis of the obtained data is presented in the last chapter (Conclusions), where the integration of biological, chemical and cultural data provides a holistic picture of Cretan populations during the Byzantine era.

The diversity of fields that bioarchaeology draws from (for example, biology, chemistry, social sciences) reflects the fact that humans more than any other living organism experience a complex interaction between physiology, culture and the environment. The interpretation of this interaction – which usually affects human remains in multiple and not always clear ways – is the bioarchaeologist's primary task. Since the mid-1980s the changes seen in the field of bioarchaeology demonstrate an increasing sophistication, which permits us to share Larsen's enthusiasm when noting that:[34]

> Bioarchaeology is enjoying a period of robust growth.

The same spirit of vitality and innovation in bioarchaeology is shared among specialists working in Greece. The increasing number of publications has stimulated a series of events convened to highlight the burgeoning of bioarchaeological studies in Greece.[35] Currently, a number of institutions support and promote the study of human skeletal remains in Greece (university departments in Athens, Rhodes, Thessalonike, Thrace and Heraklion; the Ephorate of Speleology and Palaeoanthropology; the Wiener Laboratory of the American School of Classical Studies at Athens), offering a rich environment for fruitful work. Recognizing the significance of modern reference collections for research and teaching purposes, such a collection is currently housed at the Department of Animal and Human Physiology at the University of Athens.[36] The establishment of such a collection highlights the emergence of a clearly science-based discipline in Greece. It is also promising to see that archaeologists are incorporating into their research projects the study of human skeletal remains and encouraging the presence of a specialist in the field. They also understand the benefits of integrating the results of such an analysis into the general discussion of the funerary and cultural context, rather than including a separate appendix at the end of a cemetery report.

It is very important to emphasize the hope that bioarchaeological studies will further promote the interest of all related specialists in the education of the general public on the scientific value of human remains, a task that can be

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[34] Larsen 2006, 373.

[35] In 2003 Dr L. Schepartz and Dr S. Fox organized a colloquium on *New Directions in the Skeletal Biology of Ancient Greece* at the 104th Annual Meeting of the Archaeological Institute of America; the following year, the author organized a session on *Studies of Bioarchaeology in Greece* at the 15th European Meeting of the Palaeopathology Association. The participants in these sessions, along with other scholars pursuing research on Greek skeletal populations, were invited to contribute to an edited volume; Schepartz, Fox and Bourbou 2009. Finally, in 2006 Greece hosted at Santorini the 16th European Meeting of the Palaeopathology Association, continuing a successful line of previous meetings in other European countries.

[36] The first part of the collection was built between 1996 and 1997 at the Wiener Laboratory and consisted of 72 skeletons, see Pike 1997; currently the *Modern Reference Collection of the University of Athens* includes 225 specimens, see Eliopoulos, Lagia and Manolis 2007.

accomplished if bones take an actual place in museum halls.[37] A brief survey of how skeletal remains are displayed in museum exhibitions designed to teach people that archaeology discovers not only elaborate structures and precious artifacts but also the remains of the people who actually produced them, is limited to a handful of examples. While artifacts derived from funerary contexts are displayed and presented with much detail, the associated skeletal remains are usually absent. The Kerameikos Museum in Athens hosts only one funerary urn with cremated remains – and that is the only visual presence of human remains in a museum devoted exclusively to the finds retrieved from an extensive burial ground (Figure Intro. 1).

Figure Intro. 1 A funerary urn with cremated human bones. Kerameikos Museum, Athens (photo: C. Bourbou)

37 At the Syntagma Metro Station in Athens, the exhibition of the finds recovered during construction work includes the display of a fourth century BC grave with its in situ skeleton. Feelings of passengers crossing the station daily varied from discomfort to curiosity, but no one passed by indifferent. Visitors are usually gathered around similar displays when they exist in Museum halls (for example, at the National Archaeological Museum in Athens). For a brief discussion on the display of human remains in museums, see Roberts 2009, 30–33.

In a more optimistic view, though, it must be highlighted that several temporary exhibitions have devoted a special section to the wealth of information we obtain from the study of human remains when observing pathological conditions and their treatment, diet or genetic affiliations (*Minoans and Mycenaeans: Flavors of their Times*, National Archaeological Museum of Athens, 1999), or have reconstructed burial environments including the skeletal remains (*Eleutherna: Polis, Acropolis, Necropolis*, Museum of Cycladic Art, Athens, 2005). A truly innovative way of displaying human remains has been admired by visitors at a recent exhibition (*Andritsa Cave – Fateful Refuge*, Byzantine and Christian Museum, 2005): bare bones were not exhibited; instead a sandy outline was carefully arranged to mimic the actual position of the skeleton as found within the burial context.

It is hoped that in the near future archaeologists and biological anthropologists will work together so that skeletons will come out of their closets, revealing secrets of their past lives. The bioarchaeological approach applied to Byzantine populations from Crete is expected to be such a stimulus for future analyses in Greece, especially for cases in which documentary and archaeological evidence is scarce and incomplete. The solid background of the discipline in Greece and the increasing interest in multidisciplinary applications to archaeological projects demonstrate a field where fruitful research is yet to be done.

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Chapter 1
The Jigsaw Puzzle of Health in Context

The attainment of health is one of human life's many challenges, and the study of health and disease patterns in a population can potentially reflect many aspects of how a society functions. Health and disease as variables may affect the social, political and economic systems of a society and, in turn, those systems may influence disease load on a population. The relationship between humans, their environment and cultural context (the 'ecosystem') is interdependent. Thus, the etiology of a disease may be the result of a number of factors, both intrinsic (the immune system, age and sex) and extrinsic (subsistence, diet, population density, levels of hygiene, geographical location and climate). In the complex interrelationship of these intrinsic and extrinsic influences on health, none of them acts in isolation. Using the evidence of these variables for the reconstruction of health and disease patterns in the past can be particularly difficult, as critical information may need to be deduced from inadequate or incomplete data.[1]

The immune system is the key to protecting humans from disease. The ability of a person's immune system to resist disease depends on both the natural immune system, which is genetically inherited, and the adaptive immune system, which can change to protect the body against pathogens upon being exposed to them. A strong association exists between the immune status and diet, as a healthy balanced diet contributes to the normal development and effectiveness of a person's immune system. One's age and sex can also have an impact on a person's disease experience, often because of related changes in immune responses.[2]

What people do for a living, what they eat and where they live all affect their acquisition of diseases.[3] Social inequalities present in both past and modern populations define the quality of life and affect disease frequency in rich and poor; so, for example, high-status individuals have access to better diet, living conditions and medical treatment in comparison with their poorer counterparts. The type of settlement (rural or urban), its location (for example, in a marshy

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1 For a thorough discussion, see, e.g., Roberts and Manchester 2005, 1–20; Roberts and Cox 2003, 2–12.

2 Armelagos 1998.

3 The impact of environmental and cultural factors on human health and disease has been a subject of extensive investigation; see, e.g., Salares 1991; Hope and Marshall 2000; Horden and Purcell 2000.

area) and local climatic conditions, especially weather extremes, influence the disease load on a population. The link between hot climates – which favor the survival of disease vectors – marshy areas and malaria provides a clear example of how climatic conditions, general topography and geology intertwine.[4] Agriculturally and pastorally based societies tend to develop specific health problems (for example, infectious and metabolic conditions, zoonotic diseases) as a result of sedentism, population density, poor sanitation and a limited food base. At the start of sedentism, people lack both effective sewage and clean water supplies, and accumulate domestic waste.[5] It takes only a single infected water-pump for an epidemic of cholera to spread, as was the case in nineteenth-century London.[6] Hygiene is not only environmental; although personal hygiene is culturally defined and influenced, individuals' effectiveness in cleaning their bodies, clothes, households and food affects the sanitary levels at which a population lives.

The factors briefly outlined above form the complex web that may affect an individual's predisposition to developing a disease. However, in the jigsaw puzzle of health, adaptation to a continuously changing environment also holds a fundamental role. Apart from their use of cultural mechanisms to adapt to their environment (such as medical practices), humans also deal with illness and potential disability through genetic adjustments to changes at a population level and through physiological adjustments to changes on the individual level.[7] Clearly, humans have demonstrated their ability to alter their environments in order to adapt to occurring changes. To what extent such alterations are beneficial or detrimental is uncertain, though, as changes carry with them new challenges and new risks that populations may or may not be able to deal with.

The present book aims to consider health and disease in Crete during the Byzantine period through a bioarchaeological approach, thereby contextualizing the biological evidence in the culture of the selected society. To this end, the present chapter provides an overview of the society's particular cultural conditions, all of which had the potential to affect the health status of the population: the history, archaeology, environment and natural phenomena, settlement patterns, economy and diet, general living conditions and social dynamics. Against this context, the derived biological data can then be projected, to yield a better understanding of

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[4] The geographical and meteorological location of particular sites has long been perceived to predispose populations to the development of specific diseases or to enhance the maintenance of good health. One of the most vivid examples of such notions is the Hippocratic treatise on *Airs, Waters and Places*; see Jouanna 1996; Nutton 2004, 72–86.

[5] Cohen 1989.

[6] Learmonth 1988.

[7] McElroy and Townsend 1996.

the interacting human and environmental factors that predispose, enhance or buffer the development of specific pathological conditions.

Historical Outline

The history of Byzantine Crete is scantily documented in both the textual and archaeological record. The greater emphasis given to prehistoric and classical antiquities has resulted in a relative neglect of Byzantine sites, few of which have been properly excavated and investigated, and even fewer of which have been the subject of detailed publication.

The general turbulence in the Balkan Peninsula during the fifth and sixth centuries does not appear to have affected the peaceful life of the island. A possible invasion by the Vandals in the sixth century had no documented consequences. The Slavic raids had far less effect on Crete than in the rest of Byzantine Greece. The written sources mention only one Slavic raid on the island, occurring in AD 623; and even if Crete suffered other Slavic raids, it was apparently too remote to be a focus of Slavic invasion.[8] The hypothesis of a Slavic presence on Crete has been rejected, further, on the evidence of archaeological findings, including the bronze buckles discovered at Eleutherna that have now been firmly reclassified as Byzantine.[9]

The peaceful and uneventful life of the sixth and the first half of the seventh century, a period of great prosperity on Crete, underwent dramatic changes upon the appearance and rapid expansion of the Arabs. Raids started soon after the Arabs developed as a powerful naval force in the Mediterranean basin, and resulted in general instability in the region. The first known Arab raid was in AD 654, and during the course of the eighth century Crete had become the object of repeated Arab attacks, culminating in the gradual occupation of the island between AD 827 and 828.[10] Byzantine sources often provide vague and/or inaccurate accounts of this event, but some Arab sources preserve more reliable testimonies. The success of the Arab expedition is best explained as a consequence of the administrative and defensive organization of Crete at that time. Prior to the Arab invasion, and at the beginning of the conquest, Crete was an *archontia* governed by *archons* and thus lacked the more sophisticated organization of a *theme*, particularly on the military level.

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8 Tsougarakis 1988, 22.

9 For a detailed discussion, see Poulou-Papadimitriou 2002; 2004b, 240–43.

10 Panagiotakis 1961-62; Tsougarakis 1988, 22–6, 30–41; Christides 1984; Makrypoulias 2000.

Figure 1.1 Ruins of buildings at Eleutherna (photo: courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

The fifth century on Crete was marked by the presence of natural disasters, including earthquakes (Figure 1.1).[11] The seismic action persisted in the succeeding centuries, resulting in minor and major interruptions of everyday life.[12] These exceptional disasters added to the usual and constant hazards of rural life that included unpredictable droughts, infestations of locusts, hot dry summers and bleak winters. Written references to early Byzantine famines, shortages and epidemics, mainly of plague, sporadically include the island of Crete. The historian Procopius, for example, records a major outbreak of plague in AD 541 that originated in Egypt and quickly spread throughout the eastern

[11] Platakis 1950; Di Vita 1979/80; Pirazzoli 1986, 2004; Pirazzoli, Laborel and Stiros 1996.

[12] Di Vita 1997 refers to destruction of Gortyn by either one or possibly two major earthquakes.

Mediterranean, including Crete.[13] In the Vita of Andreas, Archbishop of Crete, is attested an epidemic (presumably an outbreak of plague), coinciding with famine and drought, to be dated probably shortly before AD 740.[14] The form of the episode is stereotypical – that of the holy man who prayed for the cessation of the crises, followed by ample rain that swept the disease away – but the core may be historic.[15] Frequent suffering in the Balkan area from epidemics and other crises, such as famine and shortages, is documented also in the written sources. Stathakopoulos, in his meticulous survey of crises in the later Roman and early Byzantine era, found that the Balkans experienced 13 crises of famine and shortages (eight during the sixth and five during the seventh century) and 11 epidemics (nine during the sixth and two during the seventh century).[16] Although it is difficult to assess patterns of range and duration of crop and food crises, Patlagean argues that a famine becomes catastrophic if these conditions persist over at least two consecutive annual cycles and if stocks have been exhausted.[17]

Readily apparent in the archaeological record is the abandonment of buildings and sites in Crete during the seventh century. At Eleutherna, for example, coinage dating to the end of the reign of Constans II (AD 661–668) or possibly to the first years of the reign of Constantine IV (AD 668–674) is considered the *terminus post quem* for the abandonment of the site.[18] Comparison of sites that are sufficiently documented by architectural and numismatic evidence, such as Eleutherna and Gortyn on Crete and other sites elsewhere in the Empire, attests a fairly undifferentiated continuity of social and economic life, even as populations at extramural and less protected sites, as at Eleutherna and Gortyn, moved for greater safety to mountainous and walled locations.[19]

The Byzantines tried numerous times to reconquer the island from the Arabs, and after a succession of failures, Nicephoros Phokas in AD 961 brought Crete back into the Byzantine domain.[20] His successful expedition is an historic

13 For outbreaks of plague in the sixth to the eighth centuries in the Byzantine Empire, see Congourdeau 1993a, 21–9; Stathakopoulos 2007a; Sarris 2007.

14 *Vita Andreae Cretensis* (ed. Papadopoulos-Kerameus 1898); 177–8; Detorakis 1969-70, 93; 1970-71, 119–20; Stathakopoulos 2004, 367.

15 Stathakopoulos 2002.

16 Stathakopoulos 2004, 23–34, tables 2.4 and 2.5.

17 Patlagean 1977, 82. For a thorough review of the social response to these crises, see Stathakopoulos 2004, 56–87, esp. pp. 81–5.

18 Sidiropoulos 2000; Themelis 2004, 62.

19 Di Vita 2000, 29; Themelis 2004, 69. See also the relevant discussion based on the pottery finds in Yangaki 2005, 311–13.

20 Tsougarakis 1988, 41–58.

event about which a great deal is known, with reasonable certainty, from both Byzantine and Arab sources.[21] Following the re-establishment of Byzantine rule on Crete and the subsequent incorporation of the long-isolated island into the ecclesiastical and administrative framework of the Empire, we have almost no contemporary information concerning the social and economic conditions on the island for more than a century. It is only from later sources and indirect indications that we gain an impression of this period as one of quiet and creativity, characterized by a noted increase in monetary circulation, agricultural production and stock-raising. During this period, and increasingly during the Comnenian period (AD 1081–1185), Crete ensured its safety and strengthened its ties with the imperial capital. This direct and unquestionable influence of Constantinople is strongly evidenced in contemporary art, including architectural features and wall-paintings as, for example, in the church of Zoodochos Pigi in Alikianos, southwest of Chania, dating to the fourth decade of the eleventh century.[22] The revolt of Karykis during the second half of the eleventh century, which failed even to win the support of the population, is the only upheaval known to have occured until the capture of the island first by the Genoese (in AD 1204) and later by the Venetians (in AD 1210/1211).[23]

Christianity: The New Religion

Although the exact date of the Christianization of the island is not known, the Church of Crete is traditionally said to have been founded by Saint Paul, who then handed over the organization of the Christian communities to his disciple Titos. Information on the internal organization of the Church is extracted mainly from the Conciliar Acts and the Notitiae Episcopatuum of the Eastern Church.[24] By the second century AD a thriving Christian community had been established in Gortyn, and others must have existed in various towns throughout the island. The fate of the Church during the Arab occupation is obscured by the lack of relevant information in the sources. Some concessions would have been granted to the Church, but judging from the situation in other regions (for example, in Cyprus and Palestine) we can assume the presence of some kind of ecclesiastical and monastic organization.

21 For an account of the expedition, see Tsougarakis 1988, 58–74.

22 Andrianakis 2008, 261.

23 Tsougarakis 1988, 74–88.

24 Tsougarakis 1988, 197. For the organization of the Church on Crete, see Tsougarakis 1988, 197–248.

The most obvious modification of both the urban and rural environment was the construction of religious buildings, especially basilicas, during the fifth century and into the second half of the sixth century.[25] The great number of basilicas built in the latter period may be connected to the victories of Justinian against the Vandals and Ostrogoths and also to the island's importance as a crossroads of commerce.[26] The introduction of Christianity to the island inevitably brought new ideological and religious concepts into the society. Facilitated by the *Pax Romana* and supported by monastic activity in the east, Christianity spread throughout Greece.[27] The success of Christianity, however, did not result in the elimination of the pagan world-view, which was deeply rooted in the everyday life of most people, and its persistence is especially apparent in the area of burial rituals.[28] Due to the teaching of the new religion about the resurrection of the body, the practice of cremation went into decline, in favor of inhumation, as early as the second century, and was eventually abandoned in the fourth. Reflecting aspects of religious and social change and new ideological conceptions of death and the afterlife, burial practices in this instance responded to the Christian conception of death as *koimesis* rather than *thanatos*.[29] These changes are clearly represented in contemporary Christian texts and symbols, epitaphs and grave goods, which become fewer and less valuable in conformity with the simple and humble Christian life.[30]

Settlement Patterns and Byzantine Houses

The investigation of settlement patterns in Byzantine Crete relies mainly on the reports of geographers and travelers, hagiographical texts and archaeological evidence (namely the basilicas, defensive constructions, pottery and numismatic finds). The relevant literary evidence is scant, in many cases laconic and not

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[25] For the role of the Church in early Byzantine topography and life, see Saradi 2006, 385–432.

[26] Sanders 1982; Rendini 1985.

[27] Cameron 1993; Brown 1998.

[28] On pagan monuments in the Christian city, see Saradi 2006, 355–84.

[29] Kyriakakis 1974; Abrahamse 1984; Emmanouilidis 1989; Kourkoutidou-Nikolaidou 1997; Dennis 2001; Velkovska 2001; Alexakis 2001; Saradi 2006, 432–9. For the relevance of current Greek funerary practices to understanding Byzantine customs, see Danforth 1982; Alexiou 2002.

[30] For a survey of Byzantine cemeteries and other funerary constructions throughout Greece and for useful comments on the typology of the graves and accompanying goods, see Laskaris 2000.

always reliable, while the archaeological evidence enables us to recognize a larger number of settlements.[31] The works of early geographers and Renaissance travelers, although offering interesting information on economy, trade and customs, are of limited value in respect to the geography and topography of the island. For example, the sixth-century *Hieroclis Synecdemos*, which despite its omissions probably lists settlements active at that time, and the description of the island by Cristoforo Buondelmonti in the fifteenth century, are among the few accounts that distinguish the status of settlements.[32] Especially in the case of the earliest works, the focus on 'cities' overlooks other kinds of settlements.[33] The same incomplete picture is characteristic of the relevant hagiographical texts, with the possible exception of the autobiographical work of Ioannis Xenos from the end of the tenth and beginning of the eleventh century.[34] Although economic prosperity is evident in the archaeological evidence after AD 961 and well into the twelfth century, contemporary written sources refer more often to villages than to settlements of urban character, providing only sporadic references to Chandax (Heraklion). This change in focus undoubtedly reveals two historical trends: first, a disinterest in resettling the urban centers, and secondly, a 'ruralization' of the island. Evidently, the contribution of rural settlements to the economic growth played an important role in their survival throughout the period of Arab occupation.

The documentary and archaeological evidence attests a succession of distinctive settlement patterns. The fifth through the seventh centuries present thriving settlements primarily agricultural in character but containing a considerable urban environment, as, for example, at Gortyn. Between the seventh and ninth centuries, amid a notable lack of large-scale activities, the population appears to be organized in small rural communities, a tendency that continued into the next centuries. The Arab occupation contributed to the decay of the already declining urban centers, and the re-establishment of Byzantine rule after AD 961 did not restore the necessary economic and social conditions for an urban revival. Until the twelfth century, when urban expansion can again be detected, Chandax remained the only recognizably urban settlement, in contrast to settlements that were little more than oversized villages.

The role of rural households (farms) in the economic and social life of the island is obscured by the poverty of the architectural testimony. Evidence of

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31 For a review of settlement patterns in the light of documentary and archaeological evidence, see Tsougarakis 1988, 91–153, and 1991, 591–4, 596–9.

32 *Hieroclis Synecdemos* (ed. Honigmann 1930); *C. Buondelmonti* (ed. van Spitael 1981).

33 Saradi 2006, 96–100.

34 *Vita of Saint Ioannis Xeni* (ed. Tomadakis 1948).

rural structures rarely comes to light. A recent rescue excavation at the site of Kefala, near Vryses in northwestern Crete, has revealed evidence of a wide range of activities carried out at one rural household.[35] Located near the river Almyros and along a road artery leading to Cydonia (Chania) that had been well known since Roman times, the farm structure consisted of five rooms. Four of the rooms served as storage areas, as indicated by the presence of pithoi bases on the floor and built-in benches, and the fifth room is characterized as a workshop of uncertain type. The open space to the west of the excavated area has been identified as a courtyard, and finds from the site include a circular construction, most probably a silo, and two hearths. On the evidence of coins and pottery, the building dates to the sixth or early seventh century AD. Although we cannot infer much about the contribution of this particular farmhouse to the surrounding economy, a considerable number of farmhouses and rural settlements may have existed in the fertile plains around urban centers like Cydonia and Gortyn.[36] Such farmhouses might have acted as intermediary points for the sale of products in the closest urban center, thereby contributing to the economic growth of the island as early as the sixth and seventh centuries AD.

We can expect that extensive documentation on individual houses within these various types of settlements could tell us much about the communities that inhabited them.[37] The limits of our present data on Byzantine houses, however, allow us to draw few conclusions of more than local significance.[38] Evidence for

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35 Fiolitaki 2010.

36 Tsougarakis 1991, 593.

37 Few studies have dealt satisfactorily with the topic of Byzantine housing. Early studies by de Beylié 1902 and Gerland 1915 did not draw on the archaeological evidence and included many inaccuracies; the substantial research presented by Orlandos 1937, which remains fundamental, was limited to the houses of Mistra; and the studies by Koukoules 1936, 1951, 249–317 relied exclusively on documentary sources. More recent and substantial contributions to our understanding of Byzantine architecture include Scranton 1957 on the Byzantine levels at Corinth; Bouras 1982-83 and Sigalos 2004a, critical overviews of houses from the tenth to the fifteenth century; Sigalos 2004b, 71–78, survey of houses in post-Roman Greece; Ellis 2004, an analysis of the typology of early Byzantine houses; Grünbart and Stathakopoulos 2002, 314–19, an overview of houses and households; and Sodini 2004, a thorough discussion of findings in the Mediterranean.

38 Bouras 1982-83, 1. Discovery of a variety of items in addition to architectural remains could provide substantial information on aspects of everyday life: ceramic, glass and metal vessels (on kitchenware and storageware, see, e.g., Bakirtzis 2003; Papanikola-Bakirtzi 2005; on glass vessels, see, e.g., Stern 2001; Volanakis 2002; keys, locks and padlocks (on the technology used for the safety of houses, see, e.g., Vikan 1982); ceramic and metal lamps (on the lighting equipment, see, e.g., Petridis 1986; Oikonomou 1988). See also examples in Tsakalos 2005, 22–5, and Papanikola-Bakirtzi 2002, 272–7, 282–303.

early Byzantine houses is particularly scanty. The early Byzantine settlement at Eleutherna includes houses built hastily of material reused from earlier structures. The densely occupied neighborhoods of this era, located probably south of the basilica, remain unexcavated (Figure 1.2).[39] At Gortyn, in the area between the temple of Apollo Pythios to the west and the Praetorium to the east, a residential quarter of peasants and artisans was constructed, probably after an earthquake in the mid-fifth century. The houses, which were two storied, had small rooms and a court opening onto the street. Successive reconstructions of these houses were carried out until the demise of the city around AD 670.[40]

Figure 1.2 Room of an early Byzantine house at Eleutherna with storage pithoi (photo: courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

The study of middle Byzantine houses provides a more complete picture of a contemporary household.[41] In the tradition of antiquity, the courtyard was the focal point of the house in respect to communication between rooms and as the setting for domestic activities such as cooking, household production and small-scale manufacturing. The location of kitchens remains unclear, as hearths within

39 Themelis 2002, 105–8, and 2004, 64–5; see also Greco et al. 1998 for the late Roman/early Byzantine (fifth to seventh centuries AD) house complex at Itanos, Crete.

40 Di Vita 2000, pl. LXI; Giorgi 2002; Zanini 2003, 2004.

41 Sigalos 2004a, 55–65; Rheidt 1991; Rosser and Donovan 1983.

rooms have not been identified.[42] Although we cannot reject the possibility that particular areas within rooms or even specific rooms were reserved for cooking, it seems more likely that cooking took place in the courtyard. Storage rooms are more easily recognized, particularly on the evidence of pithoi sunk into or resting on the surface of floors. In addition to such courtyard houses, 'single-space' houses were also very common in Byzantine Greece. These structures took one of two forms: either a single room used for all household activities or two or more rooms arranged in a line or in an L-shaped plan, in which a spatial distribution of activities was probably expected. For either type of single-space house, 'a multifunctional space hypothesis' can be assumed, where the main living area served as the space for the activities of the family during the day and for resting during the night.[43] Built-in benches discovered in some rooms could have been used for seating and sleeping, and in the absence of these structures the floor could have been used, covered by the relevant sleeping equipment.[44] The only known example of a Byzantine house on Crete dating from the twelfth to the thirteenth centuries is the house excavated at the site of Pyrgi (Hagia Anna) at Eleutherna.[45] The one-story house with a courtyard consisted of three areas, set in a row, and was divided into at least six or seven smaller rooms. Area A served as the main room, area B most probably served as storage space and area C was the kitchen.

The practice of using the rooms of a house for multiple functions recommends the keeping of basic standards of personal hygiene and household cleanliness. By the Byzantine period, standards of personal hygiene were changed from those of antiquity, the ancient custom of visiting public baths having been replaced by less frequent personal washing at home. For clothes-washing, the Byzantines retained the ancient use of various kinds of earth, plant substances and wood ash, and perhaps also nitron, one of the most widespread cleaning agents of antiquity, which would foam when combined with ammonia or vinegar.[46] The extent to which thorough cleaning was possible has not been determined. Certainly in the context of densely occupied houses or settlements and close contact with animals,

[42] Only in the case of Neon Syllaton at Veroia has a hearth been possibly identified, see Pazaras and Tsanana 1990, 359, fig. 4.

[43] Sigalos 2004a, 60.

[44] Oikonomides 1990, 209–10. On the basis of eleventh to fifteenth-century documentary evidence on household contents of the middle class, Oikonomides provides information on several categories of furnishings, including chests, sleeping equipment, kitchenware and storage vessels; see also Koukoules 1949, 60–116.

[45] Kalpaxis 2008, 14 and note 6, proposes a typological correspondence with Pergamon house type d 1 or d 2.

[46] Forbes 1995, 174–82; Rautman 2006, 49.

the ill effects of poor sanitation would have resulted in a faster and more efficient transmission of disease.[47] Although there have been references in the sources to dug cesspits, construction of clay pipes from house to house and central pipes within an extended drainage system, specific sanitary facilities have not been located in houses.[48]

Economy and Society

Estimating the extent of farming and herding activity on Byzantine Crete relies on the evidence of the geographical location, climate and geomorphology; natural disasters and invasions; and also on specific historical factors such as the economic policy of the Byzantine Empire, since, for example, the size of a tax burden could affect the abandonment of fields.[49] Some aspects of the economic activity already known from the Roman period likely continued through the Byzantine period.[50]

Crete is described in the sources as a very fertile and intensively cultivated island with orchards, fruit gardens and vineyards.[51] Agriculture formed the basis of the economy and products were sufficient for both local consumption and considerable exports.[52] Grain production, in particular wheat, was the dominant agricultural activity of the population, rising well above local requirements to allow for exports and donations to various institutions.[53] Wine production, although very few references to it exist in Byzantine sources, was second in

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47 Russell 1986, 144 noted that the subdivision of the areas within households to accommodate larger numbers of inhabitants was a typical phenomenon of declining standards of everyday life.

48 Koukoules 1951, 307–13; Karpozilos 1989; Sigalos 2004a, 59. Pits have been found, for example at Corinth (see Scranton 1957), but their function has not been securely determined. A pit and open pipes for rainwater have been found at Eleutherna; see Themelis 2004, 64.

49 See, e.g., Laiou 2003 on the factors affecting the price of land during the tenth century.

50 For a general discussion of the Byzantine economy, see Morrisson and Sodini 2002; Lefort 2002; Dagron 2002.

51 In addition, *Kitâb al-Dja'rafiyya* (ed. Hadj-Sadok 1968), 70, 87, refers to a wide range of medicinal and aromatic herbs that grew in the island, such as resin, laurel and epithyme. Hazelnuts, rhubarb and pomegranates were also known to be cultivated.

52 For means of agricultural production, see Bryer 2002; on the early Byzantine agricultural tools from Eleutherna, see Brokalakis 2004.

53 Tsougarakis 1988, 282–3.

importance.[54] The production of olive oil seems to have been more limited, making imports necessary.[55] The cultivation of flax and cotton must have been known during the Byzantine era. Breeding-stock of sheep, goats and cattle was also herded as a resource for wool, rawhide and dairy products.[56] One of the best-known products of Crete was cheese, highly appraised in a number of Arabic sources, which was produced especially in the White Mountains area of the west and was exported in large quantities.[57] Also well reputed was Cretan honey, and apiculture was common.[58] Fishing must have been a subsidiary activity, especially for the coastal populations.[59] Arabic sources note that tuna, in particular, was caught in large quantities during their migration period toward Spain and Crete in early May.[60] It is reasonable to assume that freshwater fish were also consumed, especially in areas near rivers and springs. The discovery of 63 fishing-net weights made of lead during the excavation at the early Byzantine site of Argyroupolis reinforces this hypothesis. The site is located some 7 kilometers from the coast and much closer to the river Mouselas, where it is probable that most of the local fishing took place.[61] Finally, trade in ores and minerals (mainly copper and iron),

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[54] *Vita of Saint Ioannis Xeni* (ed. Tomadakis 1948), 59–60.

[55] Olive oil and walnuts are the only two agricultural products known to have been imported into Crete. It was only in the seventeenth century that Venice made the cultivation of olive trees compulsory in all her colonies; see Tsougarakis 1988. *Kitâb al-Dja'rafiyya* (ed. Hadj-Sadok 1968), 52–4, refers to some kind of oil extracted from turnips and oil derived from sesame seeds.

[56] *Vita of Saint Ioannis Xeni* (ed. Tomadakis 1948), 60.

[57] See, e.g., *Edrisi* (tr. Amadée Jaupert 1836-40) II, 126; *Aboulféda* (tr. Reinaud and MacGuckin de Slane 1848), 276; *Kitâb al-Dja'rafiyya* (ed. M. Hadj-Sadok), 54 and §358, where Cretan cheese is attested to have been exported to Egypt.

[58] *Aboulféda* (tr. Reinaud and MacGuckin de Slane 1848), 276; *Vita of Saint Ioannis Xeni* (ed. Tomadakis 1948), 59. Archaeological remains of beehives have been found at the early Byzantine sites of Eleutherna, see Yangaki 2005, 162–3; Gortyn, see Albertocchi and Perna 2001, 533–5; Panormo, see Kalokyris 1955, 325; Hagia Galini, see Vogt 1991–93; Knossos, see Frend and Johnston 1967; Hayes 2001, 440–41; and Vafes, A. Fiolitaki, pers. comm. 2008. Yangaki 2005, 163 notes that sherds from beehives found at Eleutherna account for 1 to 5%, a percentage that remains steady between the fourth and seventh centuries, suggesting a continuous local production of honey during the early Byzantine period.

[59] To what extent marine resources formed a basic supplement to the everyday diet is still under investigation; see Chapter 4.

[60] *Kitâb al-Dja'rafiyya* (ed. Hadj-Sadok 1968), 17, 40, 61. In the fourth poem of Ptochoprodromos, however, tuna is considered to be of low quality; see *Ptochoprodromos* (tr. and ed. Eideneier 1991), IV 109, 115, 237, 296.

[61] A. Fiolitaki pers. comm. 2008. The river Mouselas was known to be navigable in antiquity, as excavations undertaken by the 25th Ephorate of Prehistoric and Classical Antiquities revealed anchorages alongside the river.

timber, glass and salt was also conducted, although its relation to the economy was clearly subsidiary.[62]

The rich and prosperous island of Crete could provide a potentially well-balanced diet for those who had access to basic and seasonal foodstuffs. In urban areas a greater variety of food was available to those who could afford to buy it, while in rural areas working peasants could at least have seasonally supplemented their diets with their own produce of fruit, vegetables, eggs, milk and cheese.[63] However, the vulnerability of the rural population to shortages that resulted from adverse weather and disease should not be underestimated. Byzantine Crete had an important advantage of near self-sufficiency, and production not only met local demand but was adequate to allow exports, limiting imports largely to products of the specialized kind. Thus, from an economic point of view, basic needs could be fulfilled when no real crises emerged; but when calamities loomed, impoverished conditions would have had a significant effect on living standards.

Little information exists on the social structure of Byzantine Crete and thus our discussion is largely based on the general patterns seen in other parts of the Empire.[64] The scattered surviving evidence demonstrates that during the fifth to the seventh centuries cultivated lands belonged to free small-holder peasants, but we do not know the extent to which prominent families may have subsequently achieved dominance. One's experience of daily life was primarily shaped in the family. The Byzantine period saw family turn sharply inward, separating the public male world more clearly from the enclosed, largely domestic sphere of women and children.[65] Our necessarily generalized picture of the role of men and women in the Byzantine society of Crete reveals, to some extent, the different expectations that the society had of men and women, and thus tells us much about the society.[66] In Byzantium, early marriage was the norm, and Byzantine legislation permitted the betrothal of a girl after the age of seven, a figure later

[62] See Tsougarakis 1988, 270–78. The copper mines in the area of Kantanos are the only mining area where a Byzantine presence is certain, although other sites, such as Argyroupolis-Lappa where lead and silver were exploited, may also have been mining centers. Timber is likely to have been an abundant raw resource, although evidence of dense forests is attested in no Byzantine documentary sources; much later, *C. Buondelmonti* (ed. van Spitael 1981), 115, 116, 118 refers to massive cypress forests on the southwest coast. Salt-pans (at, for example, Souda Bay, Elounda and Spinalonga) produced salt of good quality, as attested in the *Vita of Saint Niconis Metanoeite* (ed. Lambros 1906), 154.

[63] For a thorough discussion of the Byzantine diet as attested in the sources and the derived isotopic data, see Chapter 4.

[64] Tsougarakis 1988, 290–301.

[65] For a discussion of Byzantine childhood, see Chapter 3.

[66] Barber 1997.

raised to 12. The minimum age for marriage was 12, a practice that had much to do with concerns about ensuring both the virginity of the bride and the birth of children as soon as physically possible.[67] In the course of his lifetime a man would belong to a succession of social units: household, school, professional guild and church or monastery. Prominent roles for men were available in occupations linked with civil, military or ecclesiastical services, and men could play an active role in numerous professions, the cultivation of the land and the tending of livestock.[68] Women were excluded from the priesthood and the Church hierarchy, yet found a special place in female monasteries.[69] Women's daily routine included household activities, but for most women the central biological event in their lives was childbirth.[70] Caring for the children and being responsible for their primary education were major preoccupations, in which the variety of childhood experiences often accorded with social status.[71] Women worked in the family gardens and orchards, helped with the tending of livestock and were involved in household manufacture such as spinning and weaving. All these activities could subject them to a number of hazards and to an even higher mortality risk during pregnancy and childbirth. However, the role of women – influenced by two stereotyped female figures, the Virgin Mary (representing virginity and motherhood) and Eve (representing the sexual temptress) – was crucial to the perpetuation of the family line, and was of particular importance at the critical passages of life, namely marriage, birth and death.

Byzantine Medicine

Life in the past was difficult in both urban and rural settings. Farming, for example, was the dangerous occupation it has always been, and agricultural workers risked injury from equipment, large animals and falls. Risks from

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[67] Talbot 1997, 121.

[68] The professions of doctor, tailor and horse doctor are attested for Crete; see Bandy 1970, 47, 70–71, 126–7.

[69] For the role of women in Byzantine society, Kislinger 1989; Laiou 1981, 1982, 1985, 1992, 1999, 2000; Garland 1988, 2006; Beaucamp 1992; Herrin 1993; Nikolaou 1993, 2005; Talbot 1997; Kazhdan 1998; Kalavrezou 2003; Walker 2003; Connor 2004; professional life, Bourdara 1989; Margarou 2000; religious life, Talbot 1994, 2001; Beaucamp 2000; Constantinou 2005; political life, Beaucamp 1990; Garland 1999; Herrin 2001.

[70] Women who could not conceive were considered very unfortunate and often turned to the use of various substances and magico-religious practices; see Talbot 1997, 123–4; Fulghum-Heintz 2003, 278.

[71] For the role of children in Byzantine society, see Chapter 3.

even minor wounds, which can easily become infected and lead to permanent disability or even death, were significantly greater in the pre-antibiotic era. Although references in the literary sources point to a wide range of medicinal herbs that grew on the island, and we know of the presence of a physician from a probably funerary inscription dating to the fifth century,[72] we have no detailed accounts of medical practice in Byzantine Crete.

Until recent decades, medical historians, in general, viewed Byzantine medicine as summarized by Scarborough:[73]

> [Byzantine] medicine is one of stagnation, plagiarism of the great medical figures of classical antiquity and a somber boredom that seemingly awaited the Italian Renaissance.

However, Byzantine medicine is better viewed within the social matrix of the population it was developed to serve. Both the non-medical sources and contemporary art reveal a general awareness of medicine and medical practice in Byzantium, and shed light on the lively interaction of Greek medical history, notions of magic and astrology, traditions of folk medicine, the development of hospitals and the sophisticated medical knowledge practiced by skillful physicians in the upper strata of the Empire.[74]

Byzantine doctors successfully reworked, recombined and reorganized earlier traditions with new observations. Their ongoing activity in these pursuits is evident in the major medical works of Oribasius (c. AD 325–400), Aetius of Amida (*fl.* under Justinian [AD 527–565]), Alexander of Tralles (c. AD 525–605), Paul of Aegina (*fl.* c. AD 640, in Alexandria), Theophanes 'Nonnus' (*fl.* AD 912–59), Symeon Seth (*fl.* under Michael VII Ducas [AD 1071–78]) and many others. In these works, the influence of Greek and Roman medical tradition is constantly present, but the authors introduce useful comments and notes based on fresh observations, test modified or new applications of therapeutic measurements and attempt diagnosis on the basis of careful examination. In the manufacture of drugs, as well, some parts of the Greco-Roman tradition remain, but novelty in the use of herbs and herbals, medicinal minerals and

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72 Bandy 1970, 47 no. 18 (found at Hagioi Deka, south of Gortyn).

73 Scarborough 1984a, ix; for accounts of Byzantine medicine, see, e.g., Garrison 1921; Temkin 1962; Singer and Underwood 1962; Majno 1975.

74 See, e.g., Keenan 1941, 1944; Magoulias 1964; Constantelos 1966-67; Duffy 1984; Vikan 1973, 1984; Kessler 1971; Weitzmann 1977; Eftychiadis 1983; Nutton 1984; Bennett 2000. On hospitals, see Horden 2004, 77–99; 2005, 361–89; Crislip 2005, 100–142.

animal products indicates that the theory of drug-action has shifted and that the substances used in pharmacology have been augmented in number and kind.[75]

The specialized treatise of Paul of Aegina on sophisticated surgical operations and the practical handbook of Alexander of Tralles on therapy for the working physician indicate the presence of an active scientific community concerned for the treatment and welfare of its patients and provide information about the medical man as both practitioner and teacher.[76] In a society that balanced concern for health and for salvation, the Byzantine physician is shown to support the application of charms, amulets and folk remedies.[77] Such use of superstition and magic in medical practice reveals that the Byzantine physician was well aware of notions and attitudes tightly woven into the matrix of Byzantine society, from the lower to the upper classes. Alexander of Tralles' response to this balance is quite bold: he openly associates himself with such practices at the risk of losing his intellectual respectability. Writing in a relatively clear language, he provides a vivid example of a caring physician, practicing his profession in such a way as to meet the needs of the society to which he belongs.[78] Kazhdan, studying the image of the medical doctor in the tenth to the twelfth centuries, argues that decline in the social standing of those in the medical profession began most probably after the seventh century.[79] From the numerous references to failing and incompetent doctors at the end of the tenth century, in which they are accused of daring to match the healing power of the saint, it is probably safe to deduce that physicians had become too influential to remain unchallenged. This anti-medical movement weakened during the eleventh century, and by the twelfth century physicians and the medical profession were highly respected.

The environmental and cultural characteristics of Byzantine Crete that have been sketched here indicate in general the living conditions in which the biological profile of its populations can be properly investigated. With this context in mind, the adaptive and functional meaning of the biological data provided by the human skeletal remains can be better situated in the cultural and natural environment in which they occurred. What was really happening in Byzantine Crete is the question we are called to answer, and by approaching the question at the point where historical, archaeological and biological analysis

[75] Scarborough 1984b, 2002.

[76] *Paul of Aegina* (ed. Heiberg 1921 and 1924; tr. Adams 1834); *Alexander of Tralles* (ed. and tr. Puschmann 1878–79); for the latter see also Guardasole 2004a, 2004b, 2004c, 2006.

[77] See, e.g., Vikan 1984; Maguire 1995; Russell 1995; Vakaloudi 2001.

[78] For a thorough review, see Duffy 1984.

[79] Kazhdan 1984.

meet, we can provide groundwork for evaluating a population's adaptation to its continuously changing environment.[80]

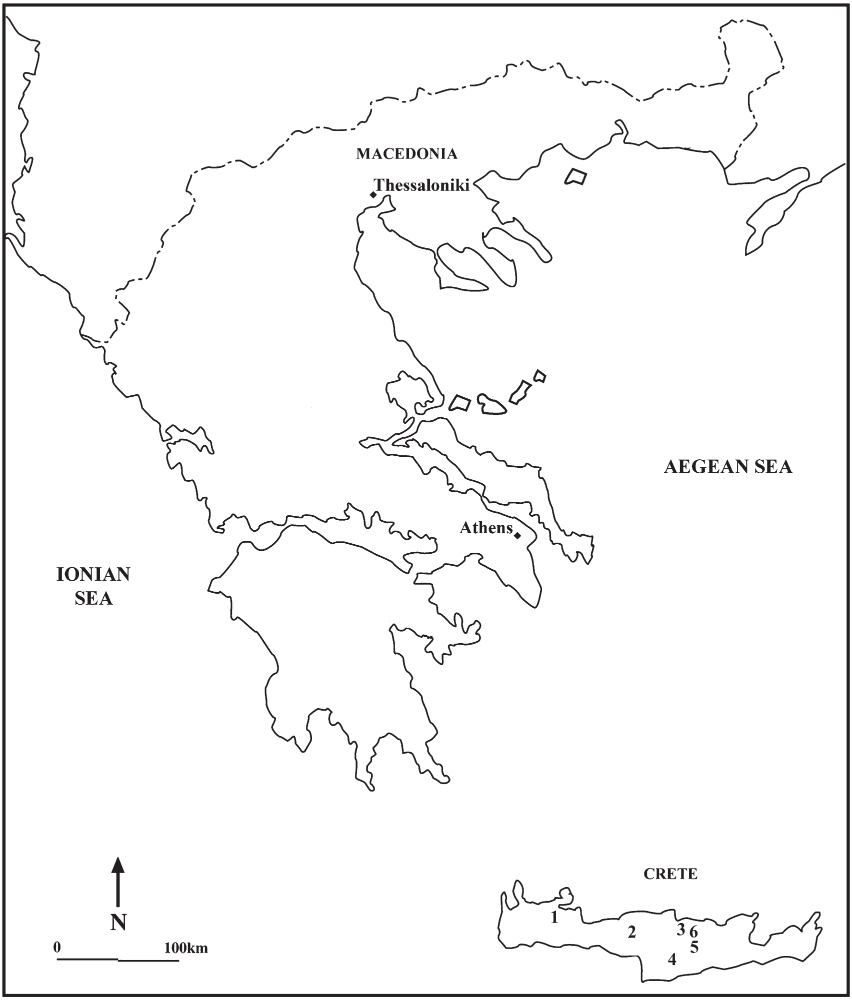

Figure 1.3 Map of the sites

*Key: 1=S*tylos; 2=Eleutherna; 3=Kastella; 4=Gortyn; 5=Kefali; 6=Knossos

[80] For application of this approach to early Byzantine populations throughout Greece, see, e.g., Bourbou 2004; Bourbou and Tsilipakou 2009. The transitional and idiosyncratic character of the period resulted in the use of differential adaptation patterns by the population under strenuous conditions; see, e.g., Bourbou 2004, 81–2 for the cases of early Byzantine Eleutherna and Messene.

Materials and Methods

Data to date published on the health of Byzantine populations from Crete is limited and varies in quality from study to study, reflecting in these respects the history of the development of bioarchaeological studies in Greece. Inadequate levels of detail and undefined methods of analysis have obscured the basis for many of the reported conclusions. The material under discussion here includes human skeletal collections studied by the author at Eleutherna, Stylos and Kastella and by other researchers at Gortyn, Kefali and Knossos, sites in the western and central parts of the island (Figure 1.3).[81] The total number of individuals is 445; 271 (60.8%) are adults and 174 (39.1%) are non-adults (Table 1.1). Of the total, 341 individuals (207 adults and 134 non-adults) represent the early Byzantine sites, and 104 individuals (64 adults and 40 non-adults) the middle Byzantine sites (Table 1.2).

Table 1.1 Demographic data for the skeletal series

Site	Date	Adult (%)	Non-adult (%)	Total	Reference
Eleutherna	Sixth to seventh centuries AD	100 (66.2%)	51 (33.7%)	151	Bourbou 2004
Gortyn	Sixth to seventh centuries AD	29 (54.7%)	24 (45.2%)	53	Mallegni 1988
Kastella	Eleventh to twelfth centuries AD	35 (59.3%)	24 (40.6%)	59	Bourbou 2006a, 2009; Bourbou and Richards 2007
Kefali	Sixth to seventh centuries AD	49 (55%)	40 (44.9%)	89	Zygouri 2005
Knossos	Sixth to seventh centuries AD	29 (60.4%)	19 (40.4%)	48	Musgrave 1976
Stylos	Eleventh to twelfth centuries AD	29 (64.4%)	16 (35.5%)	45	Bourbou 2003a, 2009
Total		*271 (60.8%)*	*174 (39.1%)*	*445*	

81 Eleutherna: Bourbou 2004; Gortyn: Mallegni 1988; Kastella: Bourbou 2006a, 2009; Bourbou and Richards 2007; Kefali: Zygouri 2005; Knossos: Musgrave 1976; Stylos: Bourbou 2003a, 2009.

Table 1.2 Demographic data for the skeletal series by time period

Early Byzantine period						
Sites	Adult	M	F	I	Non-adult	Total
Eleutherna	100	52	21	27	51	151
Gortyn	29	18	11	0	24	53
Kefali	49	18	11	20	40	89
Knossos	29	9	12	8	19	48
Total	*207*	*97*	*55*	*55*	*134*	*341*
Middle Byzantine period						
Kastella	35	15	8	12	24	59
Stylos	29	9	11	9	16	45
Total	*64*	*24*	*19*	*21*	*40*	*104*

M=Male, F=Female, I=Indeterminate

The collections of Eleutherna, Gortyn and Stylos are derived from the excavation of a cemetery of an associated ecclesiastical monument. Around the early Byzantine basilica at Eleutherna, 50 burials have been excavated. Most of them were tiled or cist graves, usually including multiple burials (Figure 1.4).[82] Although there is strong evidence that the cemetery was initially used for the burial of the clergy, it was soon used by the community at large. Accompanying goods are of great variety, including glass and ceramic vessels and jewels.

At Gortyn, in central Crete, in the area just southeast of the basilica of Hagios Titos, a densely packed necropolis was found in the ruins of a small late Antique bath complex. It was probably constructed during the last quarter of the fourth century and, after its destruction in the sixth century, it was again used until the second half of the seventh century. Almost all family tombs had been opened and reused more than once.[83] The village of Stylos, some 20 kilometers from Chania, is well known for its springs and for the river Koiliaris.[84] During excavations at the site in the 1980s and 1990s at the church of Hagios Ioannis Theologos, a large number of burials came to light (Figure 1.5).[85] Only a small part of the human skeletal collection, dating to the eleventh- to the twelfth-century phase

[82] On the basilica, see Themelis 2004, 46–63, and discussion in Andrianakis 2006, 51–2; on the burials, Yangaki 2004a; on the pottery, Vogt 2000; Poulou-Papadimitriou 2004a, Yangaki 2005; on the golden amulets, Yangaki 2004b; on the buckles, Poulou-Papadimitriou 2004b; on the inscriptions, Tzifopoulos 2000; on the coins, Sidiropoulos 2000.

[83] Di Vita 1988, 91–141.

[84] Spanakis 1993, 743.

[85] For the site of Stylos, only general information exists; M. Andrianakis pers. comm. 2009; Lassithiotakis 1969, 465–8.

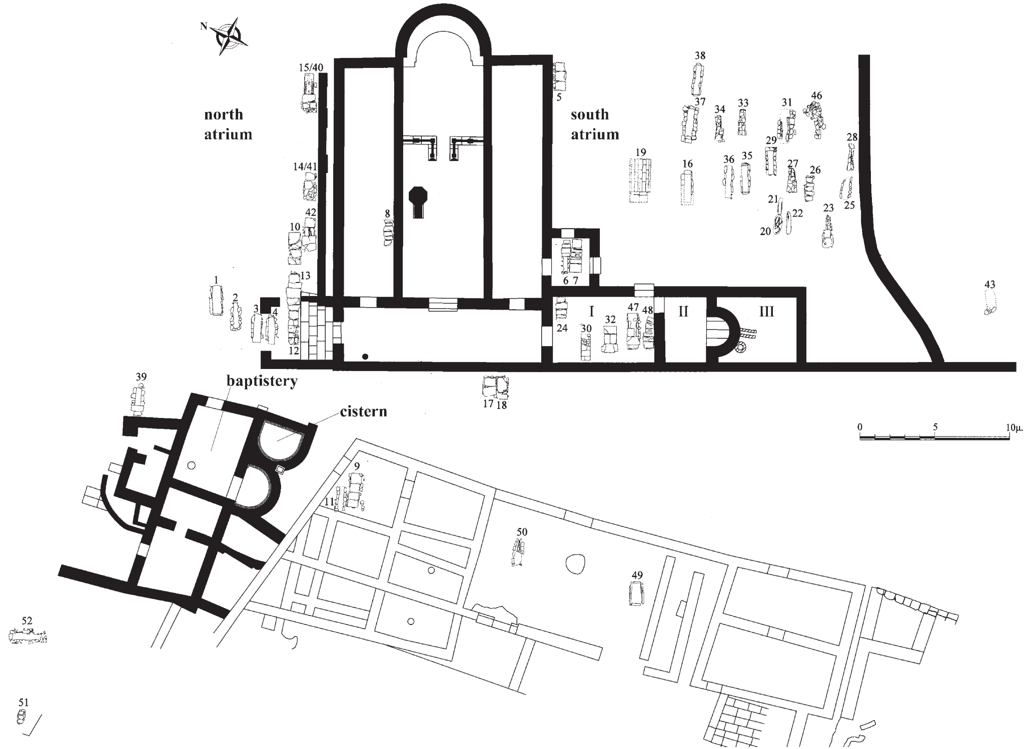

Figure 1.4 Cemetery plan of the basilica at Eleutherna (photo: courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

Figure 1.5 The church of Hagios Ioannis Theologos at Stylos (photo: C. Bourbou)

of the church, is available for study. The majority of the graves is cist or tiled. Secondary burials are frequent at the site, accounting in many cases for the disarticulation of the remains. Both adults and non-adults are represented, and the accompanying goods include jewels.

The skeletal collections of Knossos, Kastella and Kefali have not yet been associated with any ecclesiastical monument or specific settlement in the area. A built tomb (ossuary) was found on the road to Knossos, near the present-day Venizeleion Hospital in Heraklion, during excavations for the construction of a road; its chronology is based on the typology of the few clay vessels recovered among the generally poor accompanying goods. The excavators argue that this was a family tomb in use over a long period.[86] At Kastella in Heraklion, a middle Byzantine cemetery was discovered in 2003 during restoration work at the Venetian church of Saint Peter (Figure 1.6).

[86] Catling and Smyth 1976. As the ossuary contained only commingled remains, Musgrave 1976 estimated the Minimum Number of Individuals (MNI).

Figure 1.6 The Venetian church of Saint Peter in Heraklion (photo: C. Bourbou)

A total of 32 excavated burials containing single and multiple inhumations was exposed. The typology of the relatively few accompanying goods (mainly pottery and bronze jewellery) allowed for the dating of these burials to the eleventh century. In the history of the continuous occupation of the modern city of Heraklion, the discovery of this middle Byzantine cemetery is considered as the 'missing chronological link' for understanding the urban life of the city during that era.[87] Finally, in the area of Kastelli Pediados evidence has been found for continuous occupation from prehistoric to late Byzantine times.[88] In 2002, close to the top of the hillsite 'Kefali', an early Byzantine cemetery was discovered.[89]

87 Borboudakis 1968; Starida 2003; Poulou-Papadimitriou 2008.

88 Rethemiotakis 1992, 1997.

89 The excavation is not yet published. Available information on the architectural type of the graves and placement of the deceased is given in Zygouri 2005.

Anthropological Analysis

The investigation of demographic histories, differences in diet, disease and mortuary practices depends heavily on accurate age-at-death and sex estimates of human skeletal remains. The derived data used here often presented age ranges that varied considerably among the different studies and for which the methods of analysis were not always stated, making comparative analysis a difficult task. The construction of specific age categories for both adult and non-adult individuals resolved the problem presented by the various age-range systems (Tables 1.3 and 1.4). Regarding immature individuals, throughout this book the term 'non-adults' as suggested by Lewis is used,[90] including all children recovered from the sites up to the age of 17 years. Additional definitions have been used here to differentiate between the physiological periods in a child's life.

Table 1.3 Adult age categories

Age range	Definition
18–30 years	Young adult
31–40 years	Middle adult
41–50 years	Mature adult
51 years and over	Old adult

Table 1.4 Non-adult age categories

Age range	Definition
Embryo	The first 8 weeks (2 months) of intrauterine life
Fetus	From week 9 to birth
Perinatal	Around birth, from 24 weeks gestation to 7 postnatal days
Neonatal	Birth to 27 postnatal days
Infant	Birth to 1 year
Child	1–14.6 years
Adolescent	14.6–17.0 years

Adapted from Scheuer and Black 2004, 468; Lewis 2007, 2

[90] Lewis 2007, 1–2. Note that the terms applied in this study provide a biological basis for discussion and comparative analysis, rather than indication of the cultural symbolisms attributed to the Byzantine child; see Chapter 3.

The methodology for age estimation applied to the collections of Eleutherna, Kastella, Kefali and Stylos followed the criteria cited in Buikstra and Ubelaker.[91] For the documentation of age changes in adult individuals of Eleutherna, Kastella and Stylos different methods have been combined, primarily documentation of morphological changes in the pubic symphysis[92] and the auricular surfaces of the ilium,[93] dental wear[94] and cranial suture closure.[95] Age estimation of non-adult individuals was based on standards for dental eruption and development,[96] measurement of long-bone length and epiphyseal union.[97] In differentiating young adults from older individuals, special attention was given to several late-fusing skeletal elements such as the medial clavicle and the iliac crest of the ilium.

In respect to sex determination, if non-adult skeletons had been sexed in previous research, the determination was not accepted as valid; there are at present no widely agreed upon standards for diagnosing sex in immature remains. Although some advances have been made in the criteria used to sex non-adults from dry bone, the methodology needs further refinement and application to larger samples.[98] Sex in adult individuals was determined using dimorphic aspects of the pelvis and skull.[99] The pelvis is the most reliable indicator of sex in the human skeleton and, although rarely preserved intact, it was preferred to the skull. Emphasis was given to specific anatomical features such as the subpubic region (ventral arc, subpubic concavity, ischiopubic ramus ridge), the presence of a preauricular sulcus and the form of the greater sciatic notch.[100]

The estimation of stature for the collections of Eleutherna, Kastella, Stylos and Kefali followed the formulae suggested by Trotter.[101] The maximum length of only intact long bones (preferably left side bones) for each skeleton was separately estimated and then averaged.

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91 Buikstra and Ubelaker 1994; for age changes in the pelvis, see Meindl and Lovejoy 1989; and for a full discussion on ageing adult individuals, see Cox 2000.

92 Todd 1920, 1921; Katz and Suchey 1986; Brooks and Suchey 1990.

93 Lovejoy et al. 1985.

94 Brothwell 1981.

95 Meindl and Lovejoy 1985.

96 Ubelaker 1989; Scheuer and Black 2000.

97 Brothwell 1981; Ubelaker 1989; Scheuer and Black 2000; for a thorough review of non-adult ageing methods, see Lewis 2007, 38–47.

98 Lewis 2007, 47–55; Wilson, MacLeod and Humphrey 2008.

99 Determination of sex based on the cranial features is a challenging process, as cranial morphology provides a reliable basis of sex determination for only some populations.

100 The ischiopubic ramus ridge and the greater sciatic notch, considered to be the least reliable indicators, were used with appropriate caution.

101 Trotter 1970.

Paleopathological Analysis

In this book the major and most commonly attested disease categories (dental, joint and infectious diseases, hematopoietic and metabolic disorders, as well as traumatic incidents) are the pathological conditions focused on, but where evidence exists for other conditions they are also presented. For the collections of Eleutherna, Kastella and Stylos the description of pathological conditions (macroscopically and radiographically examined), stated in terms such as side/location on the skeletal element and type of lesion, followed the protocols suggested by Buikstra and Ubelaker.[102] Differential diagnosis of diseases was generally based on specialized textbooks, such as those by Aufderheide and Rodríguez-Martín, and Ortner.[103] More specifically, the criteria that have been followed for the recording of diseases are those given by Lukacs for dental diseases;[104] by Rogers et al., and Rogers and Waldron for degenerative joint disorders;[105] and by Ortner and Ericksen, Ortner, Kimmerle and Diez, and Ortner et al. for scorbutic cases;[106] cases of scurvy were re-evaluated in respect to the pathognomonic features currently suggested by Ortner, and by Brickley and Ives.[107] Recording of fractures, which formed the main body of traumatic incidents, followed a specific protocol adopted by Lovell.[108] Each skull bone (frontal, parietal, temporal, occipital, zygomatic, nasal, maxilla and mandible) was scrutinized for fractures and was distinguished by side, with the exception of the nasal bones, which were counted as one bone only. In the postcranial skeleton, the presence of fracture was determined for the long bones (clavicle, humerus, ulna, radius, metacarpals, femur, tibia, fibula, metatarsals), the thorax and the vertebral column. Each long bone was identified as present (90% present), incomplete (50–90% present), fragmentary (<50% present) or absent.[109] Both incomplete and complete long bones with fractures formed the observable corpus. For each long-bone lesion the following information was documented: side and position of bone (proximal, middle and distal diaphyses, proximal and distal epiphyses) as well as type of fracture. Long-bone fracture description included length, apposition (shift), rotation and angulation (alignment). Also assessed were aspects of fracture healing, such as duration of

102 Buikstra and Ubelaker 1994.
103 Aufderheide and Rodríguez-Martín 1998; Ortner 2003.
104 Lukacs 1989.
105 Rogers et al. 1987; Rogers and Waldron 1995.
106 Ortner and Ericksen 1997; Ortner, Kimmerle and Diez 1999; Ortner et al. 2001.
107 Ortner 2003; Brickley and Ives 2006, 2008.
108 Lovell 1997.
109 Judd and Roberts 1999.

healing (for example, the presence of complete or partial callus formation) and complications during healing.

The research data that were consulted for this study often provided only partial description of the observed lesions with reference to clinical diagnostic criteria, methodology, differential diagnosis, prevalence rates or supporting illustrations. This lack was especially apparent in the data reported for degenerative joint disease, in which prevalence rates were rarely provided. An inconsistency was also noted in 'labeling' conditions that reflect osteoarthritis, as a wide range of terms like 'arthropathy', 'arthritis' and 'osteophytosis' was applied. In general, reference to the real prevalence rates of pathological conditions according to skeletal elements or individuals was a frequent piece of vital missing information. This obstacle was possible to overcome when an inventory of bones and teeth was included in the study. If such an inventory was present, an effort was made to estimate both the number of individuals affected by a pathological condition (crude prevalence rate) and the number of skeletal elements affected (true prevalence rate). The frequencies of the pathological conditions observed in the skeletal remains from the studied sites are presented in tables that include the total number of adult/non-adult individuals; total males, females and non-sexed adults; crude prevalence rates; and true prevalence rates if total teeth/parts of bone observed are provided. In the text, crude prevalence rates are stated as a percentage of the total number of individuals considered and are graphically represented (by site/age and sex distribution/time period). The observed pathological conditions are illustrated in figures.

The bioarchaeological approach employed here for overcoming the limitations of problematic information provides, in the first instance, a window onto health in Byzantine Crete. For the future, it suggests a model for a possible standardization of methodology and improved data quality that will provide greater insight into the reconstruction of health and disease patterns from archaeological populations.

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Chapter 2
In Search of *Homo Byzantinus*

The focus in the Byzantine sources, written and visual, tends to lie on emperors, generals, the clergy and the aristocracy, of whom a great deal is known. But the 'average Byzantine' is an elusive figure that remains at the periphery of written texts and visual depictions. Investigating the concepts of gender and identity in Byzantine culture can meet many obstacles. In much early research, in fact, *Homo byzantinus* was identified as *vir byzantinus* (the Byzantine male), sustaining the idea that men were the 'natural' embodiment of Byzantine society. *Femina byzantina* (the Byzantine female) had to wait many years to leave the shadowy world to which she had been consigned.[1] The study of human skeletal remains of Byzantine populations is expected to shed more light on aspects of everyday Byzantine life and enable us to better understand what it was to be a Byzantine.

The present chapter is focused on the frequency of diseases in the adult segment of the population. The information provided, which is based on generally accepted clinical notions of disease, is discussed in light of the interaction of environmental and other influences on health status.

Table 2.1 Demographic data for the adult sample

Site	M	F	I	Total no. of individuals
Eleutherna	52	21	27	100
Gortyn[2]	18	11	0	29
Kastella	15	8	12	35
Kefali	18	11	20	49
Knossos[3]	9	12	8	29
Stylos	9	11	9	29
Total	*121*	*74*	*76*	*271*

M=Male, F=Female, I=Indeterminate

1 See Kazhdan and Constable 1982, and discussion in Barber 1997 and Bjørnholt and James 2007.

2 According to Mallegni 1988, table 1, the total number of female individuals is 16; these five additional female individuals are not included in the table as they range from 'adolescent' to 18 years old.

3 Minimum Number of Individuals and sex determination are modified after Musgrave 1976, tables 1 and 3.

Physical Anthropology

The adult sample includes 271 individuals, representing 60.8% of the total number of individuals under study. Sex determination was possible for 195 adults (43.9%), 121 males (62%) and 74 females (34.9%), while the sex of 75 individuals (10.1%) remained unknown (Table 2.1). Table 2.2 presents a summary of the data obtained from the life tables.[4] Minor and major variations were observed among the populations; for example, we note that the population of Gortyn experienced the lowest crude mortality rate (34.93 individuals), and the population of Stylos the highest (43.48 individuals). Similarly, the population of Gortyn presented the highest life expectancy at birth (28.63 years) and at age 15 (24.22 years), and Stylos the lowest at birth (23.00 years) and at age 15 (16.03 years). The data obtained is presented graphically in Figure 2.1. A cluster of deaths is observed in the most productive age categories, from 15 to 34 years, numbering 162 individuals (36.4%); at Eleutherna, for example, almost one-third of the population (58 individuals) died within this age range.[5] In the entire sample, 40 individuals (8.9%) are aged over 45 years; the populations of Gortyn and Eleutherna (12 and 11 individuals, respectively) included the majority of mature and old adult people.

Table 2.2 Summary of the data obtained from the life tables

Site	Crude mortality rate[1]	Life expectancy at birth	Life expectancy at 15 years
Eleutherna	40.13	24.92	17.97
Gortyn	34.93	28.63	24.22
Kastella	39.14	25.55	18.22
Kefali	37.20	26.88	17.21
Stylos	43.48	23.00	16.03

[1] Number of individuals dying in a year for a population of 1,000 individuals

Previous studies on early Byzantine populations indicate a mean age at death of around 40–45 years for males and 30–35 years for females.[6] These figures do not change considerably during the middle Byzantine period (Figure 2.2). The lower average age at death for females can be explained primarily in terms of the risks associated with complications during pregnancy and childbirth.

4 Life tables have been prepared for all samples with the exception of the Knossos sample, as it included only commingled remains.

5 As argued in Chapter 1, a fundamental reason for promoting teenage marriages may have been the desire to maximize the number of births.

6 Bourbou 2004, table 17. For the Roman imperial era, Angel and Bisel 1985, table 5 report that average age at death was 38.8 years for males and 34.2 years for females.

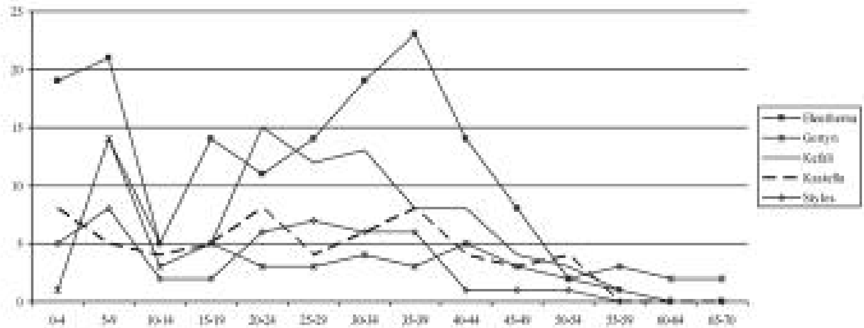

Figure 2.1 Mortality curve of the populations

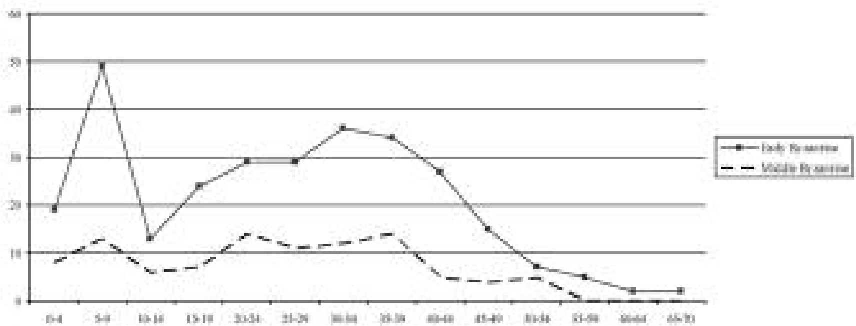

Figure 2.2 Mortality curve of the populations by time period

Possible causes include premature death due to miscarriages, complications of delivery and infection or hemorrhages during the postpartum period.[7] Based on the fact that most childbirths took place at home with the help of untrained, albeit experienced midwives, death at childbirth or shortly afterward was probably a common occurrence.[8] While women are undoubtedly put at risk by

[7] Talbot 1997, 125.

[8] Lascaratos, Lazaris and Kreatsas 2002 review a well-documented example of the difficulties confronted by physicians during the complicated labor of Eudoxia, wife of the emperor Arcadius (AD 395–408). However, evidence suggests that women also received treatment in hospitals, where beds were specifically reserved for new mothers. Talbot 1997, 124–5 and Fulghum-Heintz 2003, 280 note that the hospital in early Byzantine Alexandria had beds designated for new mothers and that the Pantokrator monastery in Constantinople (twelfth century AD) included a 12-bed female ward.

childbearing, males, in general, have a lower resistance to environmental stress and a less effective immune response than females.[9] Coupled with the hazards presented in the performance of various activities, males were also exposed to a number of risks that had the potential to put them under temporary or permanent disability, or even to cause their death.

Finally, data on average height in Byzantine Crete, although restricted by the limited number of intact long bones preserved, is estimated for males to have been between 1.61 and 1.78 cm, and for females between 1.46 and 1.62 cm (Table 2.3). These data compare with data from other Byzantine sites in Greece, apart from minor variations.[10]

Table 2.3 Mean adult height in Byzantine Crete

Site	Total no. of individuals	No. of males/ Males used for estimation	Mean height (cm)	No. of females/ Females used for estimation	Mean height (cm)
Eleutherna	100	52/16	1.69	21/7	1.60
Gortyn	29	18/11	1.73	11/3	1.60
Kastella	35	15/2	1.61	8/2	1.54
Kefali	49	18/8	~1.65	11/2	~1.48
Knossos	28	9/16[1]	1.61–1.78	12/8[1]	1.46–1.62
Stylos	29	9/3	1.66	11/0	–

[1] Number of long bones measured

Paleopathology

The distribution of the observed pathological conditions in our sample is graphically represented in Figure 2.3. Various pathological conditions that are attested include diseases of the dentition, degenerative joint diseases, hematopoietic diseases, infectious diseases, traumatic incidents, circulatory disorders, congenital abnormalities and tumors of bone. Figure 2.4 presents the distribution of pathological conditions attested in the early and middle

9 Armelagos 1998.

10 For example, at Messene the average height is 1.70 cm for males and 1.52 cm for females, see Bourbou 2004; at Corinth ('Lerna Hollow'), 1.63–1.73 cm for males and 1.50–1.62 cm for females, see Wesolowsky 1973; Abdera (Polystylon), 1.68 cm for males and 1.56 cm for females, see Agelarakis and Agelarakis 1989; at Aliki II (Thasos), 1.62 cm for males and 1.50 cm for females, see Buchet and Sodini 1984.

Byzantine periods on Crete. All pathological conditions are analyzed and discussed in detail below.

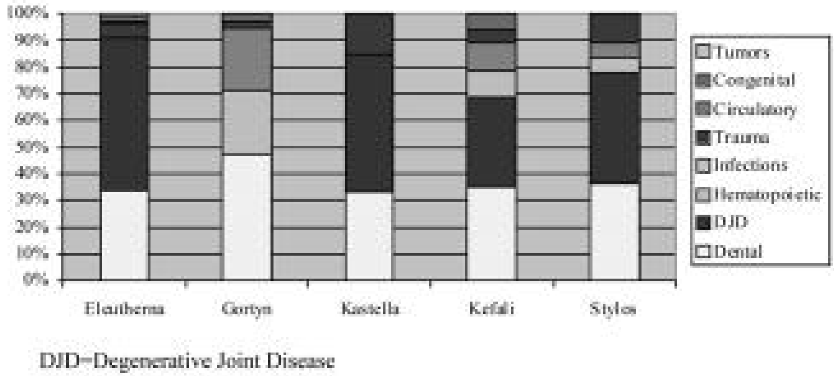

Figure 2.3 Distribution of pathological conditions by site (individuals affected)

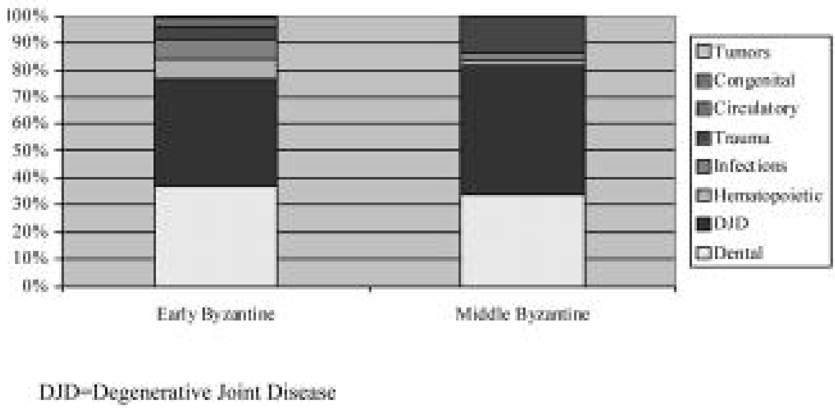

Figure 2.4 Distribution of pathological conditions by time period (individuals affected)

Diseases of the Dentition

Teeth tend to survive better than bones in the burial environment; thus dental diseases are perhaps the most commonly reported pathological conditions in any skeletal sample. Evidence of dental diseases yields valuable clues about diet (type of food consumed), nutrition (adequacy of food with regard to physiological needs) and subsistence (how that food was obtained and/or produced). In addition, the study of teeth provides information on individual health status as well as cultural influences and intercultural differences.[11] Dental diseases are classified either as infectious (when a pathogenic microorganism is responsible for the development of the condition), degenerative (due to the loss of a conspicuous amount of tooth or bone surface or substance), developmental (diseases occurring during the formation of dental tissues or during the developing interrelationship between teeth and jaws) or genetic.[12] Being able to identify the etiological pathway leading to a given dental pathology, for example, whether caries, calculus or attrition is primarily responsible for ante-mortem tooth loss – although not an easy task – is extremely useful in dietary reconstruction. However, despite a substantial bibliography on dental pathology, a full understanding of the diseases of the dentition and their implications awaits further analysis.[13]

For the purposes of this study, dental caries, ante-mortem tooth loss, abscesses, calculus (plaque or tartar accumulation) and enamel defects are considered, being the data most frequently and most consistently recorded.[14] In the sample of 271 individuals, 116 people (42.8%) suffered from dental diseases, 83 of them

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11 Cultural influences: for example, the cases of dental mutilation applied for ornamental effect in pre-Columbian America. Intercultural differences: for example, populations with varying economies have revealed important relationships between diet and the development of specific dental pathologies.

12 Lukacs 1989, 264. For a thorough review of the dental diseases most likely to be encountered and diagnosed in archaeologically recovered human skeletal remains, see Hillson 1986, 283–314; 1996, 231–94; Aufderheide and Rodríguez-Martín 1998, 398–9, 400–407; Ortner 2003, 589–606.

13 See, e.g., Hillson 1986, 1996.

14 Data on attrition and periodontal disease are much more inconsistent and are therefore excluded from the overall discussion. The available data can be summarized as follows: Mallegni 1988 associates the most frequent pathology (ante-mortem tooth loss) in Gortyn with attrition, the latter being attributed to the quality of food consumed; Bourbou 2004, table Ia, refers to only one affected mandible with periodontal disease and ten mandibles and two maxillae exhibiting heavy attrition; finally, Zygouri 2005 reports that, of 156 teeth studied, 37 (23.7%) and 12 (7.6%) presented periodontal disease and attrition, respectively.

males (42.5%) and 26 females (13.3%) of 195 sexed adults. Absolute frequency rate is 31.9% or 597 affected teeth/tooth sockets of 1,870 (Figure 2.5). Dental diseases are attested more frequently for males than females, and although all age categories are affected, a cluster is noted for middle-aged adults (Figure 2.6).

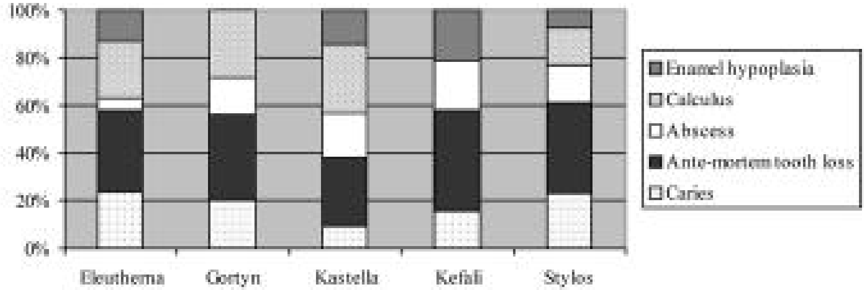
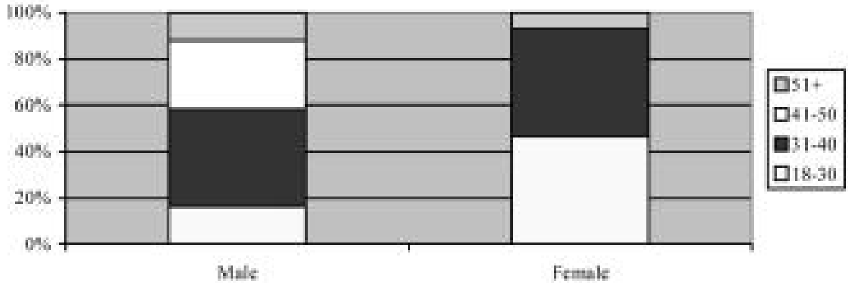


Figure 2.5 Distribution of dental pathologies by site (individuals affected)



Only individuals of known sex and age are represented

Figure 2.6 Distribution of dental disease by sex and age (individuals affected).

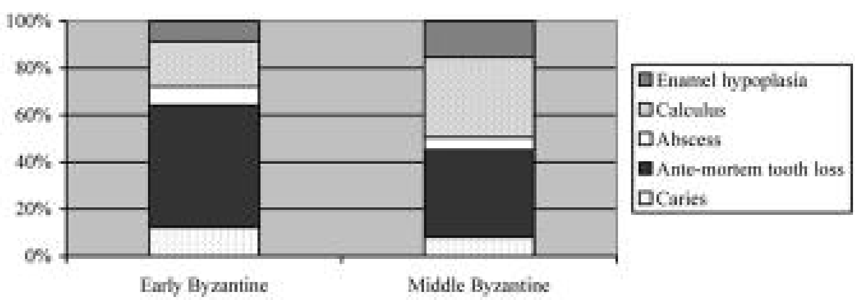


Figure 2.7 Distribution of dental pathologies by time period (individuals affected)

In comparison between time periods, 81 people (39.1%) and 35 people (54.6%) are attested for the early and middle Byzantine period, respectively. Absolute frequency rate is 27.9% or 409 affected teeth/tooth sockets of 1,461 for the early Byzantine sites, and 45.9% or 188 affected teeth/tooth sockets of 409 for the middle Byzantine sites (Figure 2.7).

The presence of food sugars in association with acidogenic bacteria produces demineralization of enamel and dentine, resulting in the formation of cavities (dental caries)[15] – Figure 2.8. Caries are recorded in all six sites, affecting 22 people, with a prevalence rate of 8.1%, representing 18 males and four females of 195 sexed individuals. Absolute frequency rate is 4.5% or 65 of 1,415 teeth, with a range of 2.1% (Gortyn) to 8.3% (Kefali) (Table 2.4).

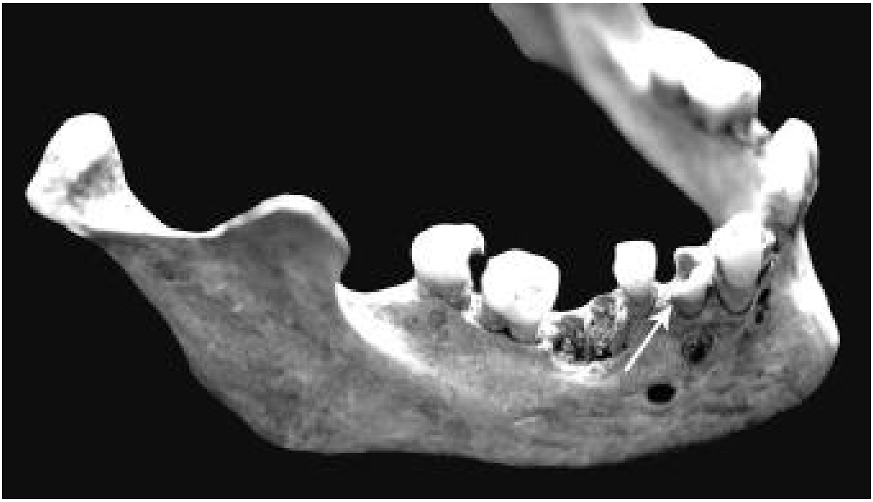


Figure 2.8 Kastella: Skeleton 014, carious lesion (arrow) on mandibular tooth (photo: C. Bourbou)

[15] Lukacs 1989, 265.

Table 2.4 Dental caries in the adult sample (individuals and/or teeth affected)

Site	Total no.	Affected	M	F	CPR%	Total no. of teeth	Teeth affected	TPR%
Eleutherna	100	9	8	1	9.0	618	18	2.9
Gortyn	29	5	4	1	17.2	232	5	2.1
Kastella	35	2	2	0	5.7	267	9	3.3
Kefali	49	3	1	2	6.1	156	13	8.3
Knossos	29	-	-	-	-	-	14	-
Stylos	29	3	3	0	10.3	142	6	4.2
Total	*271*	*22*	*18*	*4*	*8.1*	*1,415*	*65*	*4.5*

M=Male, F=Female

Lukacs describes three distinctive pathways as primary causal factors contributing to the development of ante-mortem tooth loss: caries, calculus and attrition.[16] With the exception of Knossos, for which no precise relevant data are provided, ante-mortem tooth loss is observed in the rest of the sites (Figure 2.9). The pathology is seen in 41 people (16.9%), representing 27 males and 10 females of 195 sexed

Figure 2.9 Eleutherna: Skeleton 011a, ante-mortem tooth loss (arrow) of mandibular teeth (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

16 Lukacs 1989, 265. Besides these primary causal factors, abscess and periodontal disease also cause ante-mortem tooth loss.

individuals. Absolute frequency rates for five sites are 20.0% or 283 of 1,415 teeth/tooth sockets with a range of 12.7% (Kastella) to 42.9% (Kefali) (Table 2.5).

Table 2.5 Ante-mortem tooth loss in the adult sample (individuals and/or teeth/tooth sockets affected)

Site	Total no.	Affected	M	F	I	CPR%	Total no. of teeth/sockets	Total no. of teeth/sockets affected	TPR%
Eleutherna	100	13	9	3	1	13.0	618	104	16.8
Gortyn	29	9	6	3	0	31.0	232	42	18.1
Kastella	35	6	4	2	0	17.1	267	34	12.7
Kefali	49	8	4	2	2	16.3	156	67	42.9
Stylos	29	5	4	0	1	17.2	142	36	25.3
Total	*242*	*41*	*27*	*10*	*4*	*16.9*	*1,415*	*283*	*20.0*

M=Male, F=Female, I=Indeterminate

Exposure of the pulp chamber through severe attrition or extensive carious decay produces an inflamed pulp which can result in an infected periapical tissue and osteitis. In archaeological bones such periapical abscess is recognizable if the spreading pathological process has destroyed the external bony surface of the jaw.[17] Dental abscess is recorded in all six sites, with a frequency rate of 5.9% (16 individuals), representing 13 males and three females of 195 sexed individuals. Absolute frequency rate is 2.2% or 42 of 1,870 teeth/tooth sockets, with a range of 0.3% (Eleutherna) to 12.1% (Kefali) (Table 2.6).

Table 2.6 Dental abscess in the adult sample (individuals and/or teeth/tooth sockets affected)

Site	Total no.	Affected	M	F	CPR%	Total no. of teeth/sockets	Total no. of teeth/sockets affected	TPR%
Eleutherna	100	2	2	0	2.0	618	2	0.3
Gortyn	29	4	3	1	13.7	232	7	3.0
Kastella	35	4	3	1	11.4	267	8	2.9
Kefali	49	4	3	1	8.1	156	19	12.1
Knossos	29	-	-	-	-	455	4	0.8
Stylos	29	2	2	0	6.8	142	2	1.4
Total	*271*	*16*	*13*	*3*	*5.9*	*1,870*	*42*	*2.2*

M=Male, F=Female

17 Lukacs 1989, 271. Because only visually diagnosed cases are reported in archaeological bone, the application of radiographic analysis is essential in order to assess the real abscess frequency.

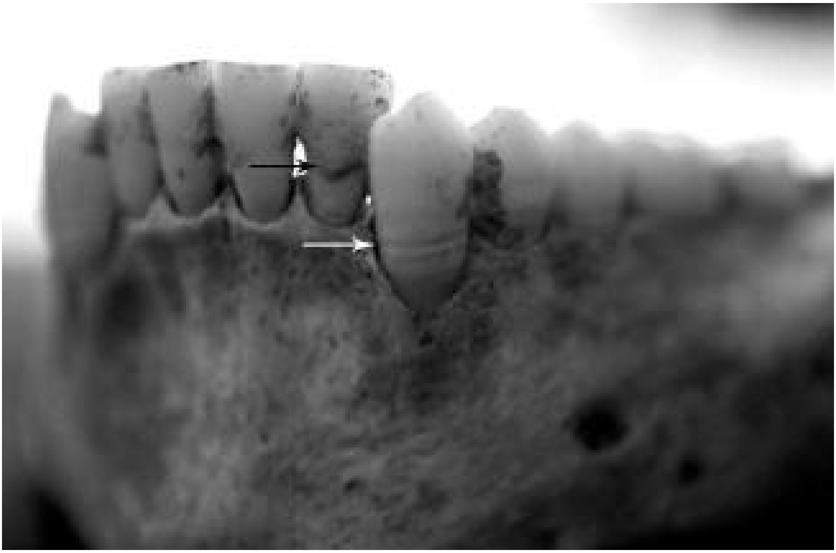


Figure 2.10 Kastella: Skeleton 021, calculus (black arrow) and enamel hypoplasia (white arrow) on mandibular teeth (photo: C. Bourbou)

Dental calculus is the mineralization of bacterial plaque[18] (Figure 2.10). Calculus is recorded in four sites, affecting 24 people (11.2%), 16 being males and six females of 195 sexed individuals. Absolute frequency rate is 12.0% or 143 of 1,183 teeth/tooth sockets, with a range of 4.5% (Eleutherna) to 32.6% (Kefali) (Table 2.7).

Table 2.7 Dental calculus in the adult sample (individuals and/or teeth affected)

Site	Total no.	Affected	M	F	I	CPR%	Total no. of teeth	Teeth affected	TPR%
Eleutherna	100	9	5	2	2	9.0	618	28	4.5
Kastella	35	7	5	2	0	20.0	267	51	19.1
Kefali	49	6	4	2	0	12.2	156	51	32.6
Stylos	29	2	2	0	0	6.8	142	13	9.1
Total	*213*	*24*	*16*	*6*	*2*	*11.2*	*1,183*	*143*	*12.0*

M=Male, F=Female, I=Indeterminate

18 Lukacs 1989, 267.

Enamel hypoplasia consists of sharply defined, linear, horizontal grooves or pits on the enamel surface of the tooth crown (see Figure 2.10). Although the classical linear lesion of enamel hypoplasia is not difficult to diagnose in archaeological teeth, atypical lesions may mimic enamel hypoplasia lines, and the anterior teeth, which are the most useful in the evaluation of the condition, are frequently lost, especially during excavation and post-excavation procedures. Enamel hypoplasia is reported in four sites for 13 individuals (6.1%), affecting nine males and three females of 195 sexed individuals. Absolute frequency rate is 5.4% or 64 of 1,183 teeth, with a range of 1.2% (Eleutherna) to 17.3% (Kefali) (Table 2.8).

Table 2.8 Enamel hypoplasia in the adult sample (individuals and/or teeth affected)

Site	Total no.	Affected	M	F	I	CPR%	Total no. of teeth	Teeth affected	TPR%
Eleutherna	100	5	4	1	0	5.0	618	8	1.2
Kastella	35	3	2	1	0	8.5	267	26	9.7
Kefali	49	4	3	1	0	8.1	156	27	17.3
Stylos	29	1	0	0	1	3.4	142	3	2.1
Total	*213*	*13*	*9*	*3*	*1*	*6.1*	*1,183*	*64*	*5.4*

M=Male, F=Female, I=Indeterminate

Teeth-cleaning appears not to have been a common activity of the Byzantine population of Crete, and the composition and consistency of foods consumed primarily determined the development of dental diseases. The quality of food consumed (sweetening agents, hard plant tissues or coarsely ground flour containing tiny stone particles from the mill-stones used for its production) affected the extent of abrasion on the teeth and pathological conditions in the oral cavity. For example, caries usually develop in the mouth in an acidic environment, while calculus usually develops in an alkaline environment, which is indicative of a more protein-rich diet. Most research suggests that the basic diet in early and middle Byzantine Crete was low in carbohydrates but rich in plant tissues and fluorides, conditions that contribute to good general oral hygiene.[19] In the samples from all six sites, ante-mortem tooth loss is the most striking of the dental diseases, and edentulous jaws have also been recovered. Two male individuals in Eleutherna had lost all their mandibular teeth ante-mortem. In the majority of cases, the smooth, completely healed dental sockets suggest that ante-mortem tooth loss must have taken place long before death occurred. The

19 See, e.g., Mallegni 1988, 46; Bourbou 2004, 71.

analysis of dental data in the samples revealed that male individuals suffered disproportionately from dental pathologies, suggesting possible differential access to food products depending on sex, but the isotopic evidence did not reveal substantial differences.[20]

Cases of enamel hypoplasia merit special attention, for paleopathologists have often interpreted individuals with hypoplasia to have been more stressed and correspondingly less well adapted than those without hypoplasia. Traditionally, enamel hypoplasia has been associated with non-fatal stress episodes, such as metabolic insults or malnutrition, although in most cases it has been impossible to associate the presence of the condition with specific etiological circumstances. Because hypoplasia is an indicator of stress, cases of enamel hypoplasia in the archaeological record are associated with hardship and are therefore important factors in elucidating the past human condition. For example, in the Eleutherna sample, an association can be made between hypoplasia, stress periods and longevity, since the mean age at death of individuals with hypoplasia is 36.8 years – appreciably lower than the mean age at death for the population overall, which is 40 to 45 years.[21]

Degenerative Joint Diseases of the Appendicular Skeleton

Diseases occurring in joints and their potential hardships (pain and disability) play an important role in any attempt to reconstruct lifestyles of past populations. The various joint diseases are typically accompanied by characteristic changes (osteophytes, erosion of the joint and especially eburnation and/or porosity of subchondral bone), enabling the researcher to classify the specific type, although in many cases, especially in fragmentary skeletons, a detailed classification is not possible.[22]

Despite the generally poor preservation of joint surfaces, degenerative diseases are among the most commonly observed pathological conditions at four of the six studied sites. At Gortyn, no degenerative lesions are reported, and at Knossos, osteoarthritis of carpal bones is summarily reported with no additional information. The report of degenerative joint diseases in the Kefali sample lacks detailed information and classification of the various types. We note here that for the Kefali sample, a case of ankylosing spondylitis has been diagnosed, but

20 See Chapter 4.

21 See the discussion in Goodman 1991; Bourbou 2004, 71–2.

22 See Rogers et al. 1987, 179–83; Rogers and Waldron 1995, 1–7.

has only been briefly described and documented as the sacro-iliac joints are not affected.

Osteoarthritis

Osteoarthritis affects synovial joints and its frequency increases with age; a predilection for the vertebral column, hands, hips, knees, the acromioclavicular joint, the first metatarsophalangeal and carpometacarpal joint is noted, and in modern populations females are usually more commonly affected than males. The typical set of diagnostic criteria for osteoarthritis on dry bone include the presence of osteophytes, areas of porosity or pitting, alteration of the bony contour of the joint and the most unequivocal marker of the condition, eburnation.[23]

Much of the work on osteoarthritis in the 1960s and 1970s considered the condition to be ideal for reconstructing past lifestyles, since its cause was largely interpreted as the result of repetitive mechanical load on specific joints; that is, the continuous use of specific muscles and joints in daily and repetitive activities.[24] Identification of osteoarthritis was used, in addition, to answer questions regarding possible links between subsistence economy and prevalence/patterning of the condition, and to track differences in activity patterns between males and females and among groups engaged in specific activities related to food production and trade.[25] Interest in osteoarthritis in anthropological studies declined in the late 1990s and although the condition continued to be incorporated in general skeletal studies, the inherent complexities of the disease process were often overlooked. Weiss and Jurmain provide a useful review of the relevant medical and anthropological research.[26] In the interest of affording better diagnoses and interpretation of osteoarthritis in past populations, and promoting a systematic evaluation of osteoarthritis as part of a more complete bioarchaeological investigation, Weiss and Jurmain emphasize the multifactorial etiology of the condition, considering genetic, anatomical, body mass index and mechanical influences on the development of the condition.[27]

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23 Rogers et al. 1987, 185–6; Rogers and Waldron 1995, 43–5; Rogers 2000, 166.

24 See, e.g., Wells 1962, 1963, 1972; Angel 1966, 1971; Ortner 1968; Jurmain 1978; Merbs 1983; Bennike 1987; Waldron 1992.

25 See, e.g., Cohen and Armelagos 1984; Bridges 1992; Lovell and Dublenko 1999; Slaus 2000; Klaus, Larsen and Tam 2009.

26 Weiss and Jurmain 2007.

27 Weiss and Jurmain 2007, 439–44.

Table 2.9 Osteoarthritis of the appendicular skeleton in the adult sample (individuals affected)

Site	Total no.	One joint affected				Two joints affected				Three or more joints affected			
		M	F	I	CPR%	M	F	I	CPR%	M	F	I	CPR%
Eleutherna	100	6	0	3	9.0	0	1	0	1.0	3	0	0	3.0
Kastella	35	1	1	0	5.7	2	0	0	5.7	2	2	0	11.4
Kefali	49	0	0	1	2.0	2	0	0	4.0	1	1	0	4.0
Stylos	29	0	0	1	3.4	0	1	0	3.4	1	0	0	3.4
Total	*213*	*7*	*1*	*5*	*6.1*	*4*	*2*	*0*	*2.8*	*7*	*3*	*0*	*4.6*

M=Male, F=Female, I=Indeterminate

Figure 2.11 Eleutherna: Skeleton 011a, osteoarthritis of the acromioclavicular joint (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

The distribution of osteoarthritis in the appendicular skeleton (Figures 2.11 and 2.12) is presented in Table 2.9. Twenty-nine individuals (10.7%) exhibited osteoarthritic lesions in one or multiple joints, 18 being males (9.0%) and six females (3.0%) of 195 sexed adults (Figure 2.13). Absolute frequency for the upper limbs is 2.7 % or 33 affected joints of the 1,193 examined, with a range of 0.6% (Eleutherna, sternoclavicular) to 9.0% (Kastella, hand) (Table 2.10).

Figure 2.12 Kastella: Skeleton 004, osteoarthritis of the knee joint (photo: C. Bourbou)

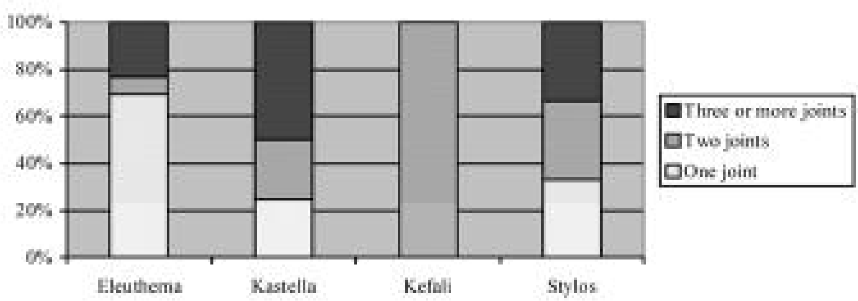

Figure 2.13 Distribution of osteoarthritis in the appendicular skeleton by site (individuals affected)

Absolute frequency for the lower limbs is 4.3 % or 21 affected joints of the 481 examined, with a range of 1.6% (Eleutherna, foot) to 19.5% (Kastella, knee) (Table 2.11). The majority of osteoarthritic lesions were observed on the upper limbs, and males are more frequently affected than females (Figure 2.14). When comparing between time periods, 18 people (8.7%) and 11 people (17.1%) are attested for the early and middle Byzantine period, respectively (Figure 2.15).

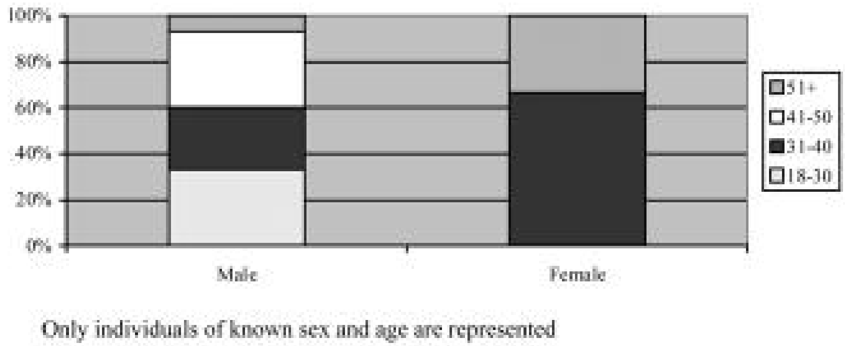

Figure 2.14 Distribution of osteoarthritis in the appendicular skeleton by sex and age (individuals affected)

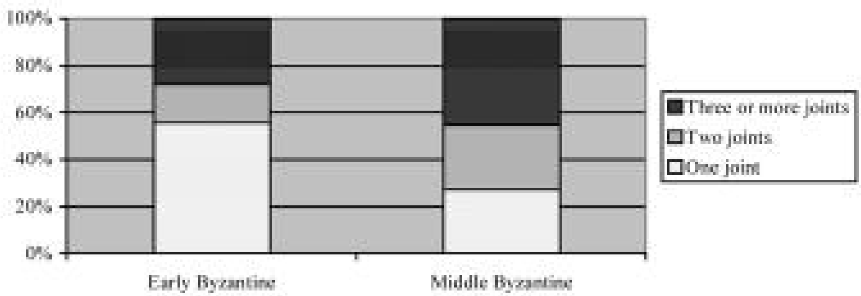

Figure 2.15 Distribution of osteoarthritis by time period (individuals affected)

Table 2.10 Osteoarthritis in the adult sample (joints affected): upper body

Site	Total joints	Joints affected	TPR%
Sternoclavicular			
Eleutherna	156	1	0.6
Kastella	24	1	4.1
Total (sternoclavicular)	*180*	*2*	*1.1*
Acromioclavicular			
Eleutherna	136	2	1.4
Kastella	45	4	8.8
Stylos	26	1	3.8
Total (acromioclavicular)	*207*	*7*	*3.3*
Glenohumeral			
Eleutherna	101	1	0.9
Kastella	41	2	4.8
Stylos	24	2	8.3
Total (glenohumeral)	*166*	*5*	*3.0*
Elbow			
Eleutherna	230	2	0.8
Kastella	48	3	6.2
Total (elbow)	*278*	*5*	*1.7*
Wrist			
Eleutherna	162	2	1.2
Hand			
Eleutherna	156	8	5.1
Kastella	44	4	9.0
Total (hand)	*200*	*12*	*6.0*
Total	*1,193*	*33*	*2.7*

Table 2.11 Osteoarthritis in the adult sample (joints affected): lower body

Site	Total joints	Joints affected	TPR%
Sacro-iliac			
Kastella	29	1	3.4
Knee			
Kastella	46	9	19.5
Foot			
Eleutherna	354	6	1.6
Kastella	35	4	11.4
Stylos	17	1	5.8
Total (foot)	*406*	*11*	*2.7*
Total	*481*	*21*	*4.3*

Degenerative Joint Diseases of the Spine

The vertebral column is also frequently affected by various degenerative conditions, mainly osteoarthritis, spondylosis and intervertebral disc displacement (Schmorl's nodes and discal prolapse). Spondylosis is a very common condition and an entity separate from osteoarthritis.[28] It affects the apophyseal (facet) joints of the vertebrae, and the most obvious manifestations include marginal osteophytes and coarse pitting of the vertebral bodies, usually manifested in mid-to-lower cervical, upper thoracic and lower regions of the spine.[29] One hundred and nine individuals (40.2%) exhibited one or multiple degenerative conditions in the vertebral column, in which the multiple conditions included coexistence of, for example, osteoarthritis and spondylosis (Figure 2.16). 68 are males (34.8%) and 23 are females (11.7%) of 195 sexed individuals (Figure 2.17). Absolute frequency is 35.9% or 400 affected vertebrae of 1,113 examined. When comparing between time periods, 71 people (34.3%) and 39 people (60.9%) are attested for the early and middle Byzantine period, respectively. Absolute frequency rate is 29.5% or 232 affected vertebrae of 786 for the early Byzantine sites, and 51.3% or 168 affected vertebrae of 327 for the middle Byzantine sites (Figure 2.18).

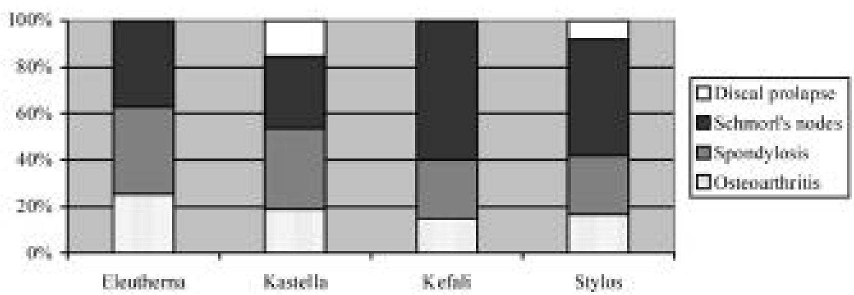

Figure 2.16 Distribution of degenerative disease of the spine by site (individuals affected)

28 Spondylosis affects the vertebral bodies and osteoarthritis affects the synovial joints of the vertebrae.

29 Rogers 2000, 169–70.

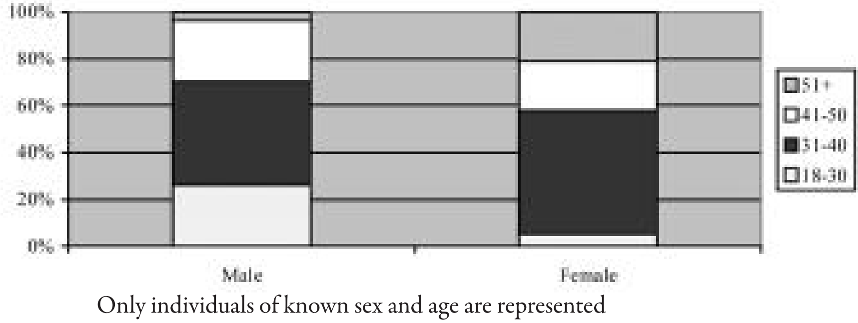

Figure 2.17 Distribution of degenerative disease of the spine by sex and age (individuals affected).

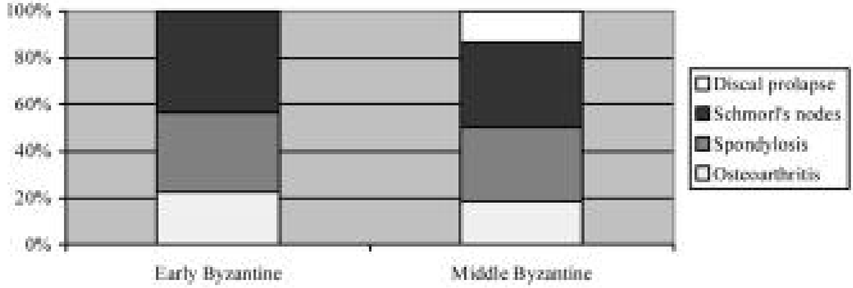

Figure 2.18 Distribution of degenerative disease of the spine by time period (individuals affected)

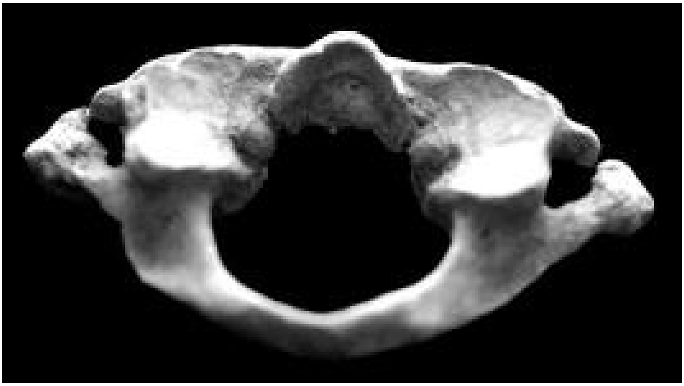

Figure 2.19 Kastella: Skeleton 011a, osteoarthritis of the first cervical vertebra (photo: C. Bourbou)

Osteoarthritis of the spine (Figure 2.19) is seen in 23 individuals (8.4%). Fifteen are males (7.6%) and six females (3.0%) of 195 sexed adults. Absolute frequency rate for spinal osteoarthritis is 7.1% or 80 affected vertebrae of 1,113 observed, with a range of 2.2% (Kefali) to 22.1% (Kastella) (Table 2.12). Spondylosis (Figure 2.20) is seen in 36 individuals (13.2%). Twenty-one are males (10.7%) and 10 are females (5.1%) of 195 sexed adults. Absolute frequency rate is 11.2% or 125 affected vertebrae of 1,113 observed, with a range of 2.2% (Stylos) to 37.5% (Kastella) (Table 2.13).

Table 2.12 Osteoarthritis of the spine in the adult sample (individuals and/or vertebrae affected)

Site	Total no.	Affected	M	F	I	CPR%	Total no.of vertebrae	Vertebrae affected	TPR%
Eleutherna	100	13	7	5	1	13.0	566	33	5.8
Kastella	35	5	4	1	0	14.2	104	23	22.1
Kefali	49	3	2	0	1	6.1	220	5	2.2
Stylos	29	2	2	0	0	6.9	223	19	8.5
Total	*213*	*23*	*15*	*6*	*2*	*10.8*	*1,113*	*80*	*7.1*

M=Male, F=Female, I=Indeterminate

Figure 2.20 Eleutherna: Skeleton 007, spondylosis of the fifth lumbar vertebra (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

Table 2.13 Spondylosis in the adult sample (individuals and/or vertebrae affected)

Site	Total no.	Affected	M	F	I	CPR%	Total no. of vertebrae	Vertebrae affected	TPR%
Eleutherna	100	19	12	5	2	19.0	566	59	10.4
Kastella	35	9	5	4	0	25.7	104	39	37.5
Kefali	49	5	3	1	1	10.2	220	22	10.0
Stylos	29	3	1	0	2	10.3	223	5	2.2
Total	*213*	*36*	*21*	*10*	*5*	*16.9*	*1,113*	*125*	*11.2*

M=Male, F=Female, I=Indeterminate

Intervertebral Disc Displacement

The intervertebral disc is a load-bearing structure that lies between the bodies of adjoining vertebrae in the spinal column. Each disc consists of an outer fibrous ring (annulus fibrosus) and an inner soft core (nucleus pulposus), both characterized by a high water content.[30] The precise amount of pressure within the disc is influenced by an individual's position and activity, and becomes elevated in the presence of abnormally increased externally applied loads, resulting in a prolapsed nucleus. Displacement of the nucleus from its confined space can result in various diseases of the spine; for example, anterior displacement can lead to spondylolysis deformans, while superior and inferior displacement is associated with cartilaginous node formation.

These cartilaginous nodes, usually termed 'Schmorl's nodes', consist of prolapsed intervertebral disc material that enters the vertebral body in a position either superior or inferior to the disc.[31] On dry bone they present as a smooth-walled cavitation seen on the inferior or superior surface of the affected vertebral body. Cartilaginous nodes are present in various disease processes, such as Scheuermann's disease (juvenile kyphosis), osteoporosis, infection and neoplasm, while traumatic incidents and senescent processes can also result from their formation. Idiopathic cartilaginous nodes, or those without obvious cause, are also encountered.[32] The predilection of Schmorl's nodes for the lower thoracic and lumbar regions is to be attributed to the anatomy and biomechanics of the lower spine, which typically result in a greater amount of loading on the lumbar vertebrae than on the cervical.[33] The presence of these nodes has been

30 Resnick 1995, 1419.

31 Schmorl and Junghanns 1959, 133.

32 Hansson and Ross 1983; Resnick 1995, 1420–21; Wagner et al. 2000.

33 Argoff and Wheeler 1998.

used as an indicator of differentiated activity patterns between males and females and among social groups.[34] In addition, the specific displacement of disc material designated as discal prolapse (protrusion), in which the nucleus pulposus has been displaced through some of the fibers of the annulus fibrosus but remains confined by the intact outermost fibers, has been observed in some of the archaeological samples under study here.[35] These conditions involving intervertebral disc displacement can provide crucial information about diseases of the disc as well as related neurological structures in a given population.

Schmorl's nodes (Figure 2.21) are seen in 45 individuals (16.6%); 28 individuals (14.3%) are males and seven (3.5%) are females of 195 sexed adults. Absolute frequency rate for Schmorl's nodes is 15.0% or 168 affected vertebrae of 1,113 observed, with a range of 10.4% (Eleutherna) to 28.8% (Kastella)

Figure 2.21 Eleutherna: Skeleton 002b, Schmorl's node (arrow) on the twelfth thoracic vertebra (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

34 See, e.g., Parrington and Roberts 1987; Robb et al. 2001.

35 Following Resnick 1995, 1424 for the terminology.

(Table 2.14). Discal prolapse (Figure 2.22) is observed in the samples from Kastella and Stylos, including five individuals (1.8%). Four are males (2.0%) of 195 sexed adults. Absolute frequency rate for discal prolapse is 8.2% or 27 affected vertebrae of 327 (Table 2.15).

Figure 2.22 Kastella: Skeleton 002, discal prolapse on the twelfth thoracic vertebra (photo: C. Bourbou)

Table 2.14 Schmorl's nodes in the adult sample (individuals and/or vertebrae affected)

Site	Total no.	Affected	M	F	I	CPR%	Total no. of vertebrae	Vertebrae affected	TPR%
Eleutherna	100	19	13	3	3	19.0	566	59	10.4
Kastella	35	8	5	2	1	22.8	104	30	28.8
Kefali	49	12	8	1	3	20.4	220	54	24.5
Stylos	29	6	2	1	3	24.1	223	25	11.2
Total	*213*	*45*	*28*	*7*	*10*	*21.1*	*1,113*	*168*	*15.0*

M=Male, F=Female, I=Indeterminate

Table 2.15 Discal prolapse in the adult sample (individuals and/or vertebrae affected)

Site	Total no.	Affected	M	F	I	CPR%	Total no. of vertebrae	Vertebrae affected	TPR%
Kastella	35	4	4	0	0	11.4	104	9	8.6
Stylos	29	1	0	0	1	3.4	223	18	8.0
Total	*64*	*5*	*4*	*0*	*1*	*7.8*	*327*	*27*	*8.2*

M=Male, F=Female, I=Indeterminate

Osteoarthritis is the second most frequently encountered pathological condition in the skeletal sample, next to dental diseases. Although osteoarthritis is a multifactorial condition, the primary contributing factors are age and mechanical stress. The presence of degenerative changes in major joints and in the vertebral column is associated with the wear and tear occasioned by everyday activities and is distinguished from traumatic arthritis, which is caused by disruption of the biomechanical functioning of a joint. Even in cases where the articular cartilage is entirely missing as a result of severe osteoarthritis, the presence of eburnation and/or porosity is a reliable indication that the joint was still in use when death occurred.[36]

Schmorl's nodes are frequently observed in archaeological populations, occurring cross-culturally and throughout various time periods, geographical locations and overall activity patterns.[37] Faccia and Williams, in a clinical study that investigated the relationship between Schmorl's nodes and pain, have provided information that is also useful in the analysis of skeletal populations.[38] The results indicated that Schmorl's nodes in the central part of the vertebral body are significantly associated with patients' reporting of pain, and that the presence of osteophytes in the affected vertebral region may increase the possibility that an individual will report pain. On the basis of that evidence, Schmorl's nodes can be expected to have adversely affected the quality of life in past populations as well. Schmorl's nodes can occur idiopathically and can be associated with specific pathological conditions, but are most commonly the result of degenerative changes associated with ordinary stress on the vertebral column.[39] Due to the non-specific nature of these indicators, etiological determinations of specific activities are not attempted here.

36 Rogers and Waldron 1995.

37 See, e.g., Kramar, Lagier and Baud 1990; Coughlan and Holst 2000; Knüsel 2000; Knüsel and Boylston 2000; Robb et al. 2001.

38 Faccia and Williams 2008.

39 Schmorl and Junghanns 1959.

What is clear from the skeletal data is that males, particularly of younger age groups, suffered more than females from degenerative joint disease. Although sex differences may be a consequence of hormones, body size and anatomy, rather than of activity, the observed pattern may be suggestive of a more strenuous lifestyle for male individuals, for whom an early onset of work is also indicated.

Hematopoietic Disorders

The general term 'anemia' includes various red blood cell abnormalities that affect the normal exchange of oxygen in the circulatory system. Anemias such as sickle cell anemia and thalassemia are the result of genetic abnormalities that affect the synthesis of hemoglobin, while other types of anemia are caused by abnormalities in hemoglobin production or retention. Iron is an important constituent of hemoglobin, and anemia can also be caused by inadequate intake of iron. Abnormal blood loss through bleeding, due to a variety of causes such as infection of the gastrointestinal tract, can also lead to the development of anemia. Diagnosis of anemia on dry bone, regardless of the specific cause of the condition, requires evidence of marrow hyperplasia. Not all anemias affect the skeleton and the association between the severity of anemia and the extent of bone involvement is still poorly understood.[40]

Cribra orbitalia and porotic hyperostosis

Cribra orbitalia refers to porous lesions on the orbital roof, and porotic hyperostosis refers to porous lesions on the cranial vault. Both lesions can result from marrow hyperplasia, which can cause a thinning of the outer table of the skull, a widening of the inner diploë (spongy bone) and a characteristic 'hair-on-end' appearance of the trabecular structure detectable on radiographs. Cribra orbitalia and porotic hyperostosis have a morphological resemblance, but it is not yet clear whether they share the same etiology.[41] A variety of etiologies has been suggested for the interpretation of these porous lesions, including orbital hemangioma or chronic eye infection in leprous individuals, trachoma, genetic

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40 For a thorough discussion of anemias, see Ortner 2003, 363–70. Lagia, Eliopoulos and Manolis 2007 discuss macroscopic and radiological characteristics associated with thalassemia, based on observation of the skeletal remains of a 14-year-old that are housed in the *Modern Reference Collection of the University of Athens*.

41 For the suggestion of an etiological relationship between the two, see, e.g., Stuart-Macadam 1989; Salvadei, Ricci and Manzi 2001; Facchini et al. 2004; no such relationship is argued in, e.g., Wiggins 1991; Ribot and Roberts 1996; Lewis and Roberts 1997.

anemias, dietary deficiency (mainly iron-deficiency anemia), parasitic infestation and infection.[42] Although cribra orbitalia and porotic hyperostosis should be viewed as descriptive rather than diagnostic terms, and despite evidence that various conditions (infections, metabolic disorders) can produce similar lesions, it is widely accepted by paleopathologists that porotic hyperostosis and cribra orbitalia are osseous responses to iron-deficiency anemia, and these lesions have become almost synonymous with iron-deficiency anemia in the bioarchaeological literature. Walker et al. have argued, however, that iron-deficiency anemia does not provide a reasonable physiological explanation for the marrow hypertrophy that produces porotic hyperostosis and cribra orbitalia. They suggest, instead, that a vitamin B12-deficient diet is much more likely to be the key nutritional component in the set of interacting variables responsible for porotic hyperostosis and many cases of cribra orbitalia.[43]

Table 2.16 Cribra orbitalia and porotic hyperostosis in the adult sample (individuals affected)

Site	Total no.	Affected with cribra orbitalia	M	F	CPR%	Affected with porotic hyperostosis	M	F	CPR%
Gortyn	29	9	5	4	31.0	0	0	0	0
Kefali	49	5	4	1	10.2	2	2	0	4.0
Stylos	29	1	0	1	3.4	1	0	1	3.4
Total	*107*	*15*	*9*	*6*	*14.0*	*3*	*2*	*1*	*3.0*

M=Male, F=Female

Cribra orbitalia is observed in 15 individuals (5.5%), affecting nine males (4.6%) and six females (3.0%) of 195 sexed adults. Porotic hyperostosis is observed in three individuals (1.1%), two being males (1.0%) and one female (0.5%) of the 195 sexed adults (Table 2.16) and (Figure 2.23). Absolute frequency rate for cribra orbitalia is 76.0% or 28 affected orbits of 37 observed, with the maximum prevalence (75.0%) at Kefali. Absolute frequency rate for porotic hyperostosis is 6.3%, or nine affected cranial bones of 141 observed, with the maximum prevalence (8.8%) at Kefali (Table 2.17). The majority of the cases include male individuals (Figure 2.24). Fourteen individuals (6.7%) are reported for the early Byzantine sites, and only one individual (1.5%) from the middle Byzantine site of Stylos (Figure 2.25).

[42] Møller-Christensen and Sadison 1963; Duggan and Wells 1964; Angel 1964a, 1966, 1971; El-Najjar 1977a, 1977b; El-Najjar et al. 1979; Cohen and Armelagos 1984; Gilbert and Mielke 1985; Walker 1986; Blom et al. 2005.

[43] Walker et al. 2009.

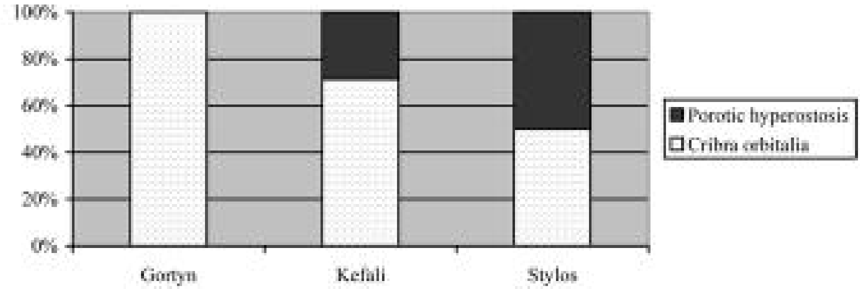

Figure 2.23 Distribution of hematopoietic disorders by site (individuals affected)

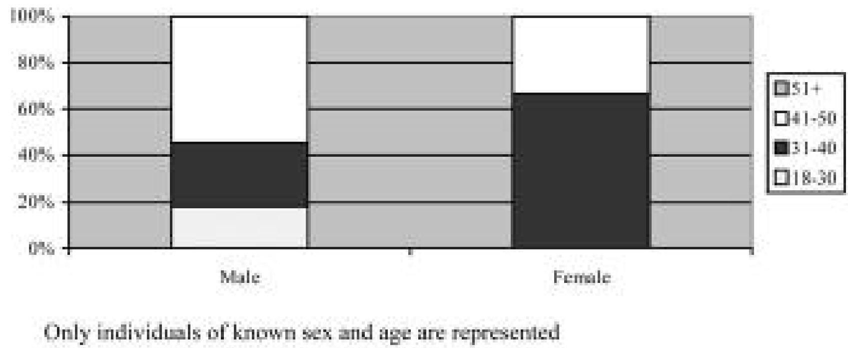

Figure 2.24 Distribution of hematopoietic disorders by sex and age (individuals affected)

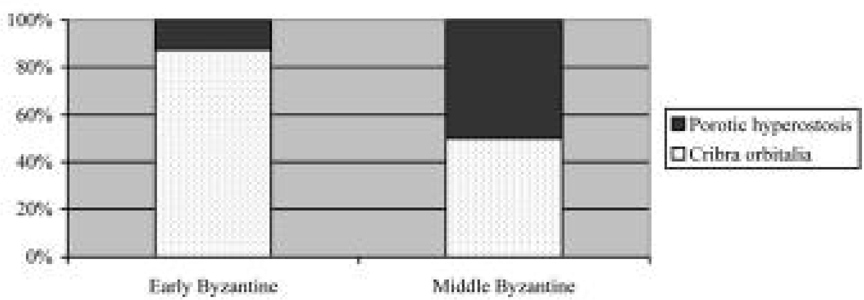

Figure 2.25 Distribution of hematopoietic disorders by time period (individuals affected)

Table 2.17 Cribra orbitalia and porotic hyperostosis in the adult sample (bones affected)

Site	Total cranial bones	Cranial bones affected	TPR%
Orbits			
Gortyn	-	18	-
Kefali	12	9	75.0
Stylos	25	1	4.0
Total (orbits)	*37*	*28*	*76.0*
Frontal			
Kefali	34	3	8.8
Parietal			
Kefali	40	3	7.5
Stylos	25	2	8.0
Total (parietal)	*65*	*5*	*8.0*
Temporal			
Kefali	42	1	2.3
Total	*178*	*37*	*21.0*

Angel's hypothesis that cribra orbitalia and porotic hyperostosis reflect thalassemia genotypes as a response to endemic malaria has influenced the diagnosis of these lesions on human skeletal remains from Greece.[44] Mallegni, for example, suggested thalassemia minor as a probable cause of the porotic lesions observed in Gortyn, adducing the marshy location of the site in the Messara plain, where a high incidence of malaria has been noted.[45] However, most recorded cases of porotic lesions fail to provide convincing evidence of genetic anemias, due to the absence of additional skeletal lesions associated with these disorders. Hapiot, having more recently investigated the impact of malaria in the ancient Aegean, from the Paleolithic to Geometric periods, concluded that the connection between malaria and the presence of porotic hyperostosis was not absolute in all surveyed sites.[46]

Current research on the subject has profited from the introduction of histological and DNA analysis, which enhances the differentiation between true cases of iron-deficiency anemia.[47] Histological analysis has been applied to investigation of the biogeographical profile of porotic hyperostosis in prehistoric

44 Angel 1964a, 1966, 1967, 1984; see also Keenleyside and Panayotova 2006; Walker et al. 2009, 112–13.

45 Mallegni 1988, 386.

46 Hapiot 2002, 2003.

47 For the application of DNA analysis to differential diagnosis see Filon et al. 1995; Faerman 1999; Faerman et al. 2000. For the application of histological analysis, see Schultz 2001; Wapler, Crubézy and Schultz 2004. The histological image indicative of iron-deficiency anemia presents gracile trabeculae, orientated in a perpendicular hair-on-end pattern extending from the diploic space.

Greece, including samples from Mesolithic, Neolithic and Bronze Age sites presenting differing environmental conditions.[48] Tentative results suggest that porotic hyperostosis exposes a broad range of morphotype variants in prehistoric Greece and that a significant relation exists between the prevalence of the lesions and the ecological settings, such as extreme environments. Still, the association of the pathology with nutritional and social shifts during the Neolithic period cannot be detected, and a combination of factors is expected to account for the prevalence of the pathology in certain sites.

The most appropriate model for paleoepidemiological studies of cribra orbitalia and porotic hyperostosis would seem to be a multifactorial etiology, although in each environmental/population niche certain specific synergistic factors would predominate. Reconsidering the etiology of porotic hyperostosis and cribra orbitalia has important implications for current interpretations of malnutrition and infectious disease in past populations. Distinction should be made, for example, between porotic hyperostosis resulting from marrow hyperplasia and porotic hyperostosis caused by superficial inflammatory conditions such as infection or scurvy. A more precise system of classification, enabling standardization between data on these lesions, would allow more scientifically valid comparison and would increase our understanding of the mechanisms responsible for their occurrence.[49]

Infectious Diseases

Infectious conditions of varying degree are very commonly found in skeletons from archaeological sites, since infection has played a significant role in human health for millennia. Perhaps more than any other category of disease, the causes and effects of infections offer skeletal biologists insight into the interaction of disease, diet, ecology, social structure, settlement patterns, plant and animal domestication, warfare, sanitation levels, immunological resistance and physiological stress. The factors affecting the prevalence of infectious conditions in populations are many and varied: they include the immune system of the host, the virulence of pathogens, ecological considerations, adequacy of nutrition and population density. A well-recognized aspect of the ecology and epidemiology of infectious diseases is the synergy between infection, malnutrition and population density. Close contact in a densely occupied settlement, coupled with the ill effects of poor sanitation, favors the spread of infectious conditions.[50]

48 Stravopodi et al. 2009.
49 Jacobi and Danford 2002; Hapiot 2003.
50 Armelagos 1990; Lambert 1993.

Researchers interested in the history and patterns of infectious diseases are confronted with problems in the analysis of skeletal remains that complicate the interpretation of data. Since bone is a very dynamic and sensitive tissue, relatively few infectious diseases produce recognizable lesions; some infectious diseases provide pathognomonic skeletal changes that could potentially contribute to a specific diagnosis (for example, syphilis), while others do not. In addition, the pattern of bone involvement can be further complicated, since several diseases can affect the skeleton in similar ways. Virtually all infectious diseases recognized in human skeletal remains have resulted from chronic conditions in which the patient survived for many years and skeletal involvement was late in the disease process. Hence, only a small number of individuals who have infectious diseases will exhibit evidence of the condition in the gross anatomy of the skeleton. In a skeletal sample, then, those skeletons showing evidence of infection are not representative of all individuals in the total sample that had infectious disease.[51] Furthermore, individuals presenting skeletal lesions have different immune responses to infection than individuals without skeletal lesions, and the more effective immune response to infection by females further complicates this difference.

Periostitis

Periosteal new bone formation has been commonly interpreted as evidence of non-specific infectious disease, and played a significant part in the 'stress-indicator hypothesis' as a sign of infectious conditions.[52] Perhaps the term 'periostitis' is poor for describing periosteal new bone formation, because it assumes by definition that inflammation has occurred. Although inflammation is not always present when a periosteal reaction arises, it frequently occurs as a general response to intrinsic and extrinsic stimuli such as trauma, neoplastic disease and infectious agents.[53] A study of pathology museum specimens failed to link definite qualitative or quantitative macroscopic and radiological characteristics of the periosteal reactions to specific diseases.[54] This finding – that lesion characteristics are shared among various diseases – is particularly important as it highlights the caution necessary in the interpretation of periosteal lesions. In particular, diagnosis of periosteal reactions from incomplete skeletons may lead to a false impression of the types of lesions occurring throughout the body, and to an overestimation of pathogen load models in past populations.

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[51] Ortner 1998.

[52] Goodman et al. 1988.

[53] See discussion in Weston 2006, 48–9.

[54] Weston 2006.

Figure 2.26 Eleutherna: Skeleton 001g, periosteal reaction (arrow) on the distal end of the tibial shaft (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

Table 2.18 Periostitis in the adult sample (individuals affected)

Site	Total no.	Affected	M	F	I	CPR%
Eleutherna	100	7	5	2	0	7.0
Kastella	35	2	0	2	0	5.7
Kefali	49	5	4	0	1	10.2
Total	*184*	*14*	*9*	*4*	*1*	*7.6*

M=Male, F=Female, I=Indeterminate

Fourteen people (5.1%) exhibited periosteal lesions (Figure 2.26), mainly on the long bones of the lower limbs, nine being males (4.6%) and four females (2.0%) of 195 sexed individuals (Table 2.18) and (Figure 2.27). Absolute frequency rate is 5.0% or 25 affected bones of 498 (Table 2.19). Periosteal lesions are observed on individuals of both sexes and all age categories, with a cluster noted for the age group 31–40 years (Figure 2.28). When comparing between time periods, 12 people (5.7%) and two people (3.1%) are attested for the early and middle Byzantine period, respectively. Absolute frequency rate is 4.7% or 22 affected bones of 461 for the early Byzantine sites, and 8.1% or three affected bones of 37 for the middle Byzantine sites (Figure 2.29).

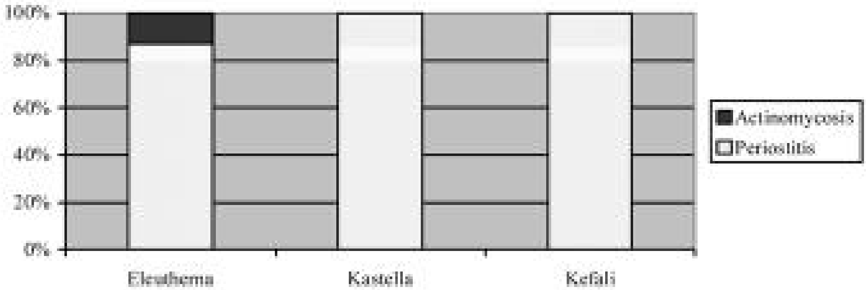

Figure 2.27 Distribution of infectious conditions by site (individuals affected)

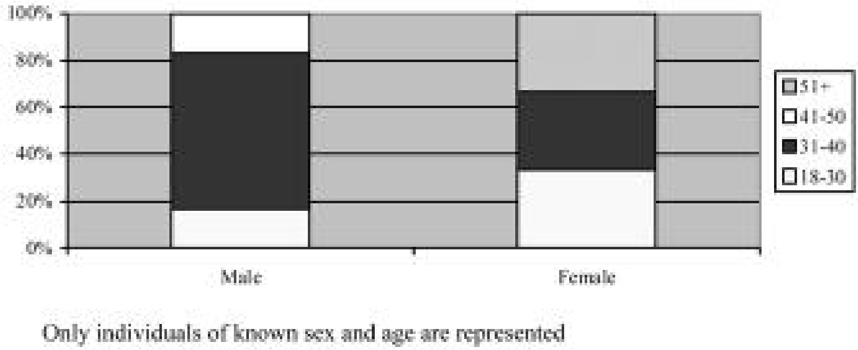

Figure 2.28 Distribution of infectious conditions by sex and age (individuals affected)

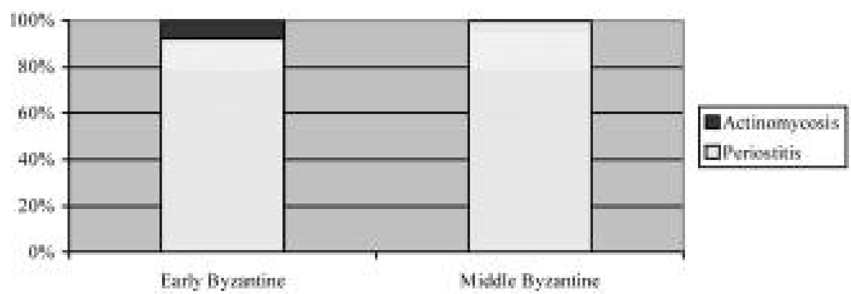

Figure 2.29 Distribution of infectious conditions by time period (individuals affected)

Table 2.19 Periostitis in the adult sample (bones affected)

Site	Total bones	Bones affected	TPR%
Femur			
Kefali	61	5	8.1
Tibia			
Eleutherna	180	5	2.7
Kastella	37	3	8.1
Kefali	55	4	7.2
Total (tibia)	*272*	*12*	*4.4*
Fibula			
Eleutherna	165	8	4.8
Total	*498*	*25*	*5.0*

Skeletal changes in the samples of Eleutherna, Kastella and Stylos studied by the author consist primarily of elevated periosteal lesions with linear striations and pitting along the shaft and distal ends of long bones, most frequently the tibia and fibula. The lesions demonstrate active but chronic inflammations suggestive of non-specific infections of presumably systemic hematogenous origin, or of a bony reaction to overlying skin trauma caused by everyday activities. There has been considerable speculation on the reasons for the localization of periosteal lesions, especially on the tibia.[55] Bones such as the tibia and the fibula, not being completely surrounded by large amounts of soft tissue during life and therefore at slightly cooler temperatures, are more susceptible to infection than bones with greater amounts of soft tissue. It is also true that bones near the skin are at greater risk of direct trauma than bones with overlying muscle. Large chronic ulcers on the skin, especially those due to venous stasis, not uncommonly result in periostitis in local bone lesions on the tibia.[56] Subcutaneous and subperiosteal bruises from trauma in some cases promote bacterial proliferation through release of blood and intracellular fluids from ruptured cells and vessels. Additionally, the anterior and lateral aspects of the tibial diaphysis have the largest and perhaps most vascular and physiologically inactive surfaces of the skeleton, which may also be conducive to bacterial colonization and infection.[57] Perhaps both of these factors are significant in the localization of the observed periostitis. The predilection of male individuals for periostitis may reflect greater exposure to repeated minor trauma to their lower limbs as a consequence of gender influences on occupations.

55 See, e.g., Coughlan and Holst 2000; Holst et al. 2001; Lee 2001.

56 Ortner 2003, 207.

57 Steinbock 1976; Martin et al. 1991; Cotran, Kumar and Robbins 1994.

Actinomycosis(?)

Actinomycosis, a chronic granulomatous, suppurative disease of humans and cattle that may be systemic or localized, is caused by the bacterium *Actinomyces israelii*, which is endogenous to the oral cavity.[58] While this pathological condition may occur at any age, cases cluster in individuals between the ages of 15 and 35 years and the male–female ratio is 2:1. The condition presents in three different forms depending on the location of the lesion: cervicofacial, abdominal and pulmonary or thoracic.[59] The thoracic and lumbar regions, the ribs, the cervical vertebrae and the sacrum are the principal sites affected in the post-cranial skeleton, although any bone may be involved.

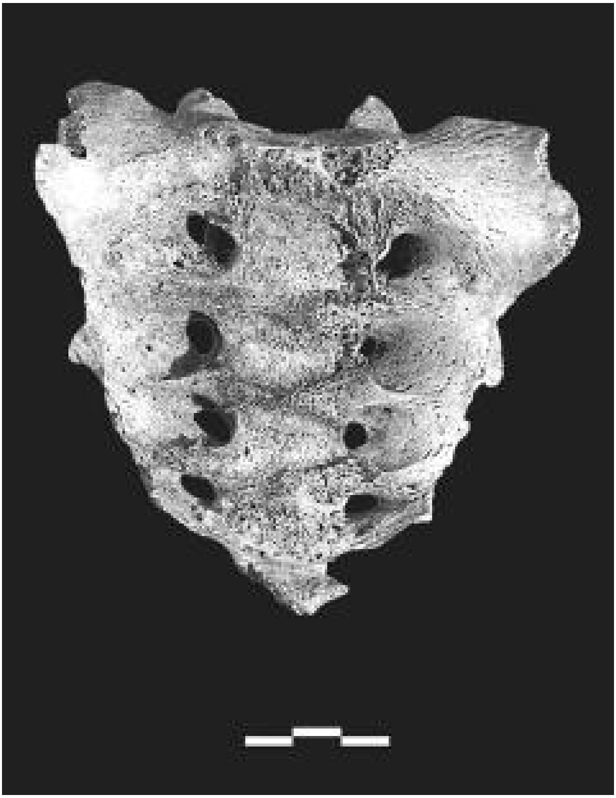

Figure 2.30 Eleutherna: Skeleton 005kg, a possible case of actinomycosis on the sacrum (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

58 Aufderheide and Rodríguez-Martín 1998, 193.

59 Robbins 1975.

A possible case of actinomycosis was recorded for the sacrum of skeleton 005kg from Eleutherna (0.3%), a young adult male around 25 years old (Figure 2.30). Excessive formation of new bone in an abnormal pattern of sharp extending spicules was noted along the transverse lines of the anterior aspect from the first to the fourth sacral foramina. The differential diagnosis of fungal infection must be excluded, since bone infection amounts to only a very small percentage of these cases, in which the morphology of the skeletal lesions is mainly lytic, with little if any perifocal bone reaction, similar to that of neoplastic disease and tuberculosis.[60] The possible case of actinomycosis reported for the Eleutherna skeleton most likely resulted from interaction between the population and its environment, specifically close contact with cattle resulting in poor sanitation.

Trauma

The record of traumatic incidents imprinted upon a skeleton may contain a wealth of information about a lifetime of encounters with the environment and fellow humans. Trauma affects the skeleton by partial or complete break in a bone, abnormal displacement or dislocation of joints, disruption in nerve and/or blood supply, and artificially induced abnormal shape of bone.[61] Trauma most commonly represents extrinsic influences on the skeleton, such as accidental or intentional violence, cultural (dental mutilation) or therapeutic practices (trepanation) and pathological conditions that might increase the vulnerability of bone to biomechanical stress (cancer and osteoporosis). Clearly, the prevalence and location of traumatic incidents are influenced by cultural factors (lifestyle), while sex and age also play an important role in the distribution of trauma patterns within a population.

Because they are among the most easily diagnosed and common types of skeletal trauma, fractures have traditionally attracted the most interest from paleopathological investigators.[62] The term 'fracture' in its broad sense describes

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60 Aufderheide and Rodríguez-Martín 1998, 213.

61 See Ortner 2003, 119.

62 Systematic work on fracture prevalence was undertaken as early as the beginning of the 20th century; see Wood-Jones 1910. During the last decades a number of papers stimulated wider interest in population studies of fractures; see, e.g., Lovejoy and Heiple 1981; Merbs 1989; Walker 1989; Roberts 1991; Berger and Trinkaus 1995; Grauer and Roberts 1996; Smith 1996; Stirland 1996; Kilgore, Jurmain and van Gerven 1997; Jurmain and Bellifemine 1997; Lambert 1997; Judd and Roberts 1999; Neves, Barros and Costa 1999; Jurmain 2001; Judd 2004; Domett and Tayles 2006; Djuri et al. 2006; Mitchell, Nagar and Ellenblum 2006;

any traumatic event that results in partial or complete discontinuity of a bone.[63] Fracture healing is a complex process that includes a number of variables, such as the bone involved (skull fractures heal more slowly than long bones), the severity of the fracture, the apposition of the ends, the stability of the fractured ends, the age of the individual (fractures heal more rapidly in children) and their nutritional status. Absence of medical treatment and inadequate immobilization of the fracture during the healing phase can result in a number of complications such as infection, bone deformity, non-union traumatic arthritis and joint fusion.[64]

The distribution of fractures in the adult sample is presented in Tables 2.20, 2.21 and 2.22. Twenty-four people (8.8%) sustained one or multiple fractures, 16 being males (8.2%) and three females (1.5%) of 195 sexed adults (Figure 2.31). Absolute frequency rate is 3.5% or 43 fractured bones of the 1,199 examined bones, with a range of 0.4% (Kefali, spine) to 11.7% (Kastella, parietal bone). As evidenced by the raw fracture data, the majority of cases occurred at the site of Kastella. In general, the majority of traumatic lesions were observed on the upper limbs and in the middle and mature adult age groups; males exhibited more fractures than females, possibly reflecting sex-based differences in activity or risk of fracture (Figure 2.32). When comparing between sites, 10 people (4.8%) and 14 people (21.8%) are attested for the early and middle Byzantine period, respectively. Absolute frequency rate is 2.1% or 13 fractured bones of 618 for the early Byzantine sites, and 5.1% or 30 fractured bones of 581 for the middle Byzantine sites (Figure 2.33).

Table 2.20 Fractures in the adult sample (individuals affected)

Site	Total no.	One fracture				Two fractures				Three or more fractures			
		M	F	I	CPR%	M	F	I	CPR%	M	F	I	CPR%
Eleutherna	100	5	0	0	5.0	0	0	0	0	0	0	0	0
Gortyn	29	0	0	0	0	0	0	0	0	1	0	0	3.4
Kastella	35	6	1	0	20.0	1	0	0	2.8	1	1	0	5.7
Kefali	49	2	1	1	8.1	0	0	0	0	0	0	0	0
Stylos	29	0	0	4	13.7	0	0	0	0	0	0	0	0
Total	*242*	*13*	*2*	*5*	*8.2*	*1*	*0*	*0*	*0.4*	*2*	*1*	*0*	*1.2*

M=Male, F=Female, I=Indeterminate

Brickley 2006; Torres-Rouff and Costa Junqueira 2006; for a thorough bioarchaeological analysis of the history of violence, see Walker 2001; Brickley and Smith 2006.

63 For a thorough review of fractures, see Resnick 1995, 2570–77; Ortner 2003, 120–26.

64 Ortner 2003, 126–36.

Table 2.21 Fractures in the adult sample (bones affected): skull, upper limbs and thorax

Site	Total bones	Bones affected	TPR%
Skull			
Parietal			
Kastella	17	2	11.7
Kefali	40	2	5.0
Total (parietal)	*57*	*4*	*7.0*
Occipital			
Kastella	19	1	5.2
Clavicle			
Kastella	24	2	8.3
Stylos	16	1	6.2
Total (clavicle)	*40*	*3*	*7.5*
Scapula			
Kastella	20	1	5.0
Humerus			
Kastella	37	3	8.1
Ulna			
Eleutherna	104	1	0.9
Stylos	24	1	4.1
Total (ulna)	*128*	*2*	*1.5*
Radius			
Eleutherna	92	2	2.1
Gortyn	19	2	10.5
Kastella	34	2	5.8
Stylos	24	1	4.1
Total (radius)	*169*	*7*	*4.1*
Hand			
2nd mcp			
Kastella	30	1	3.3
5th mcp			
Kastella	35	2	5.7
Total (hand)	*65*	*3*	*4.6*
Ribs			
Kastella	110	8	7.2
Spine			
Gortyn	44	2	4.5
Kastella	104	1	0.9
Kefali	220	1	0.4
Total (spine)	*368*	*4*	*1.0*
Total	*1,013*	*36*	*3.5*

2nd mcp=second metacarpal; 5th mcp=fifth metacarpal

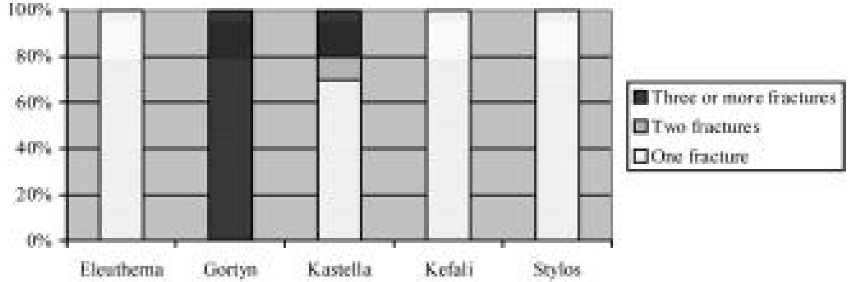

Figure 2.31 Distribution of fractures by site (individuals affected)

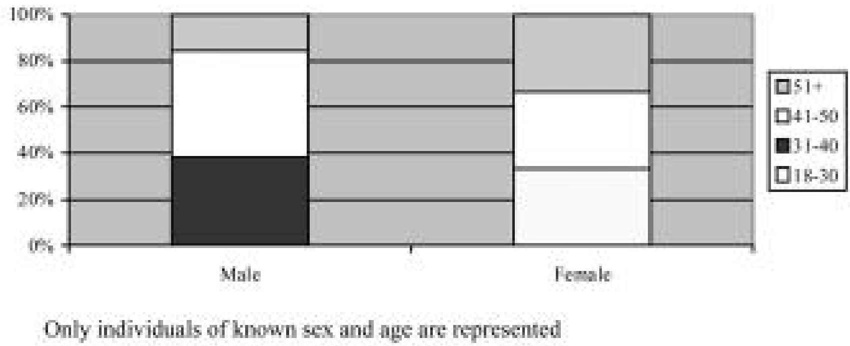

Figure 2.32 Distribution of fractures by sex and age (individuals affected)

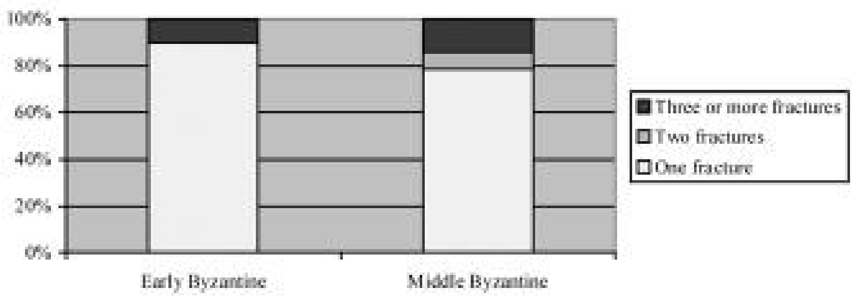

Figure 2.33 Distribution of fractures by time period (individuals affected)

Table 2.22 Fractures in the adult sample (bones affected): lower limbs

Site	Total bones	Bones affected	TPR%
Tibia			
Kastella	37	2	5.4
Stylos	22	1	4.5
(Total tibia)	*59*	*3*	*5.0*
Fibula			
Kastella	28	1	3.5
Foot			
5th mtt			
Eleutherna	99	2	2.0
Kefali	-	1	-
Total (foot)	*99*	*3*	*3.0*
Total	*186*	*7*	*3.7*

5th mtt=fifth metatarsal

Multiple Fractures

Four individuals (1.4%) from Gortyn and Kastella experienced more than one fracture. A male individual aged c. 60 from Gortyn sustained compression fractures in two thoracic vertebrae and Colles' fractures in both radii. Three individuals in the Kastella sample experienced multiple fractures (skeletons 001, 011a and 017).[65] Skeleton 001, a female c. 25 years old, suffered from a compression fracture on the fifth lumbar vertebra (Figure 2.34). Protrusion of the spinal cord and ossified nodules were observed on the superior body, while the inferior body was normal. Slight marginal osteophytosis was also present on the superior body. Five left ribs (the fifth to eighth and the eleventh) presented transverse fractures toward the neck (Figure 2.35). Callus formation is visible in all cases. Involvement of the pleura sheath in the healing process was noted in the fifth to the seventh ribs, and woven bone formation on the eighth. A transverse fracture was also observed on the distal one-third of the left tibia (Figures 2.36 and 2.37). Callus formation is visible, and the affected bone is shorter than the contralateral (Left=34 cm/ Right=36 cm). Secondary osteoarthritis at the ankle joint had developed, as evidenced by the osteophytic formation on several tarsal bones: on the plantar surface of the talus, the posterior articular surface of the calcaneus and the plantar surface of the navicular. Finally, a transverse fracture is also present at the distal end of the left clavicle (Figures 2.38 and 2.39). The affected clavicle was shorter than the contralateral (Left=10.1 cm/ Right=11 cm) and the bone exhibited angular alignment.

65 For the analysis of fractures observed in the Kastella sample, see Bourbou 2009.

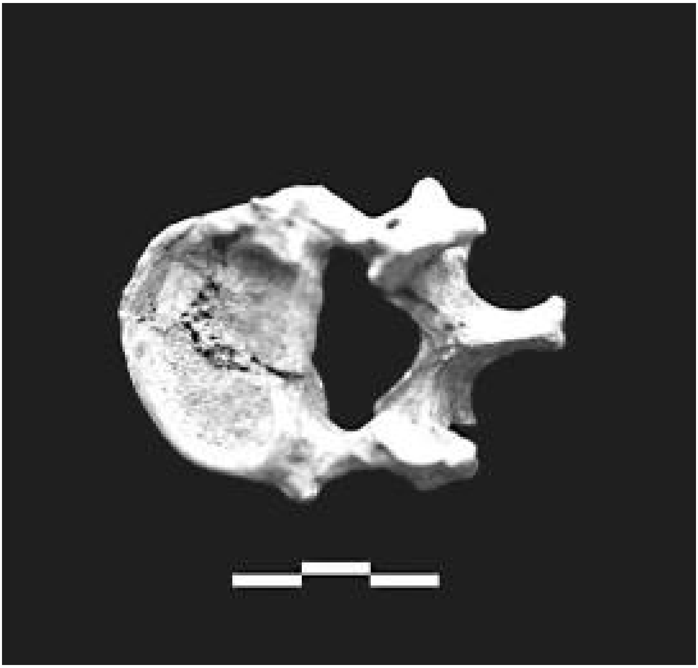

Figure 2.34 Kastella: Skeleton 001, compression fracture on the fifth lumbar vertebra (photo: C. Bourbou)

Figure 2.35 Kastella: Skeleton 001, transverse fracture towards the neck of the eighth left rib (photo: C. Bourbou)

Figure 2.36 Kastella: Skeleton 001, transverse fracture at the distal one-third of the left tibia (photo: C. Bourbou)

Figure 2.37 Radiograph of the tibial fracture of skeleton 001 from Kastella

Skeleton 011a, a male of 44 years, sustained a transverse fracture on the mid-shaft of the fifth left metacarpal (Figure 2.40). Slight callus formation is visible. In addition, the left scapula presents a sharp cut on the body (Figures 2.41 and 2.42). Complications in the healing process included a displacement of the bone fragments in the lateral border and ossified nodules due to possible involvement of the infraspinatus muscle.

Skeleton 017, a male of 35–40 years, also presents multiple fractures. Transverse fractures were observed at the mid-shaft of the right humerus, the distal one-third of the left radius, the mid-shaft of the left fifth metacarpal, the distal one-third of the left fibula, the distal end of the left tibia (Figure 2.43) and in two right and one left fragmentary ribs. Callus formation is present in all cases and complications were noted in the fractured tibia: ossified nodules are present

Figure 2.38 Kastella: Skeleton 001, transverse fracture at the distal end of the left clavicle (photo: C. Bourbou)

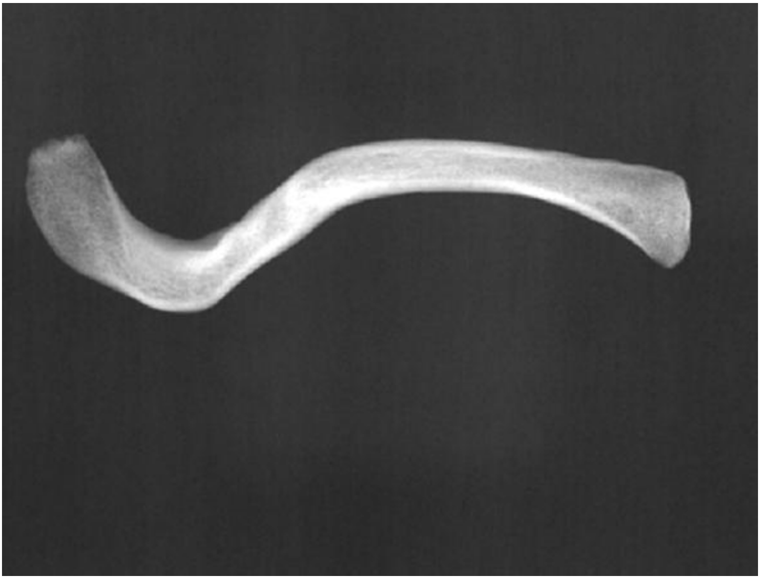

Figure 2.39 Radiograph of the fractured clavicle of skeleton 001 from Kastella

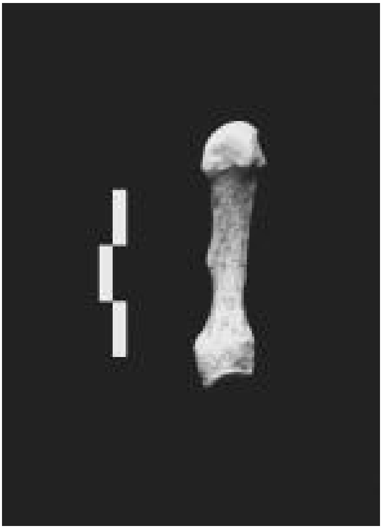

Figure 2.40 Kastella: Skeleton 011a, transverse fracture on the midshaft of the fifth left metacarpal (photo: C. Bourbou)

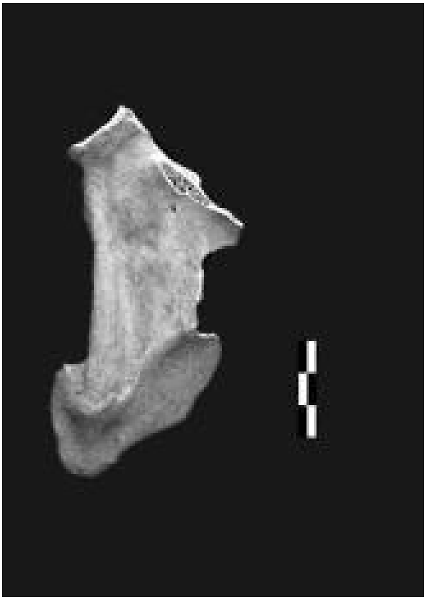

Figure 2.41 Kastella: Skeleton 011a, fracture on the body of the left scapula (photo: C. Bourbou)

Figure 2.42 Radiograph of the scapular fracture of skeleton 011a from Kastella

on the insertion of the interosseous ligament, and there is osteoarthritis of the ankle joint (marginal osteophytosis at the distal end of the tibia and the talus).

Figure 2.43 Kastella: Skeleton 017, transverse fracture at the distal end of the left tibia (photo: C. Bourbou)

Skull Fractures

Two cranial fractures were recorded for Kastella, both involving male individuals aged 30–35 years (skeleton 002) and 39 years (skeleton 014). Skeleton 002 exhibits a diagonal cut from the left parietal to the central part of the occipital bone (Figures 2.44 and 2.45). The sharp-edged defect is 10.1 cm long with a maximum width of 1.5 cm. The internal edges are sharp with no evidence of healing. Skeleton 014 presents an oval depressed skull fracture (1.1 × 0.5 cm) on the right parietal, just above the lambdoidal suture (Figures 2.46 and 2.47). Two possible depressed fractures are also observed in the right parietals of two male individuals (both aged 41–50 years) from Kefali.

Figure 2.44 Kastella: Skeleton 002, fracture extending from the left parietal to the central part of the occipital bone (photo: C. Bourbou)

Figure 2.45 Radiograph of the fracture on the skull of skeleton 002 from Kastella

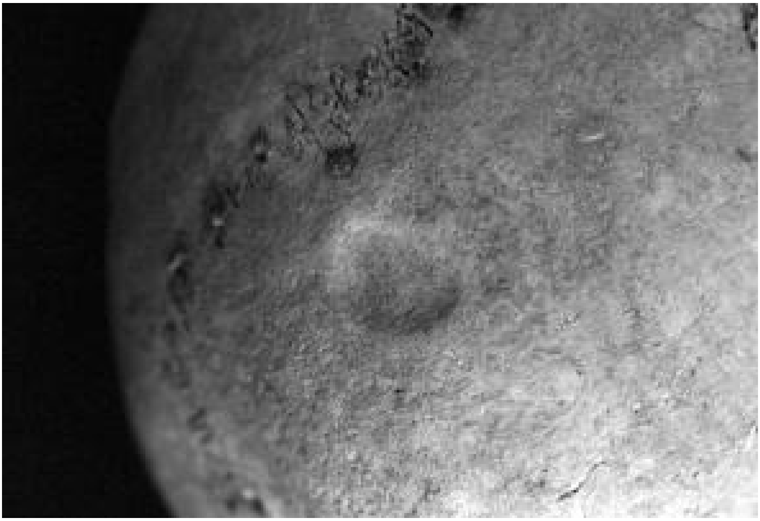

Figure 2.46 Kastella: Skeleton 014, depressed fracture on the right parietal (photo: C. Bourbou)

Figure 2.47 Radiograph of the depressed fracture on the skull of skeleton 014 from Kastella

Figure 2.48 Eleutherna: Skeleton 005ke, Colles' fracture on the distal end of the left radius (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

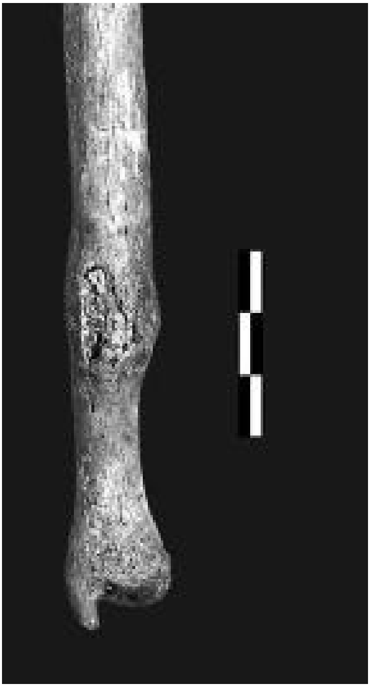

Figure 2.49 Eleutherna: Skeleton 001d, parry fracture at the distal end of the right ulna (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

Upper Limb and Thorax Fractures

Skeleton 022, a male of 35 years from Kastella, presents a transverse fracture at the distal end of the left clavicle. Angular alignment and shortening of the bone were noted (Left=14 cm/ Right=14.5 cm). Transverse fracture on the mid-shaft of the left clavicle is also recorded for an adult individual from Stylos (burial 28/1997). Skeleton 008b, a mature adult male, and skeleton 025, an adult male from Kastella, present a well-remodeled transverse fracture at the one-third proximal diaphysis of the right humerus and the mid-shaft of the left humerus, respectively. In the latter case callus formation is visible, as is additional shortening of the bone (Left=30 cm/ Right=32 cm). Skeleton 013, a male of 44 years from Kastella, suffered from a Galleazi's fracture at the distal end of the left radius. Angular alignment was observed, as well as osteoarthritis on the wrist joint in the presence of marginal osteophytosis and slight eburnation on the radius. Another adult individual from Stylos (burial 28/1997) exhibits a Galleazi's fracture at the distal end of the left radius. Colles' fractures at the distal end of their left radii are reported for two individuals from Eleutherna – skeleton 005ke, a male of 45 years, and skeleton 018, another adult male (Figure 2.48). Parry fractures are reported for Stylos: an adult individual (burial 1/1990) presents a well-remodeled parry fracture at the distal end of the right ulna, and a male individual of 54 years (skeleton 001d) from Eleutherna at the distal end of the left ulna (Figure 2.49). Regarding the bones of the hand, skeleton 023, a female of 50–60 years from Kastella, sustained a transverse fracture on the mid-shaft of the left second metacarpal. Callus formation is present, and the affected bone appears shorter than the contralateral (Left=5 cm/ Right=6 cm). Finally, a thoracic vertebra of a mature female from Kefali exhibits a compressed fracture.

Figure 2.50 Stylos: Burial 26a/1989, transverse fracture on a distal left tibia (photo: C. Bourbou)

Lower Limb Fractures

One distal left tibia of an adult individual from Stylos (burial 26a/1989) exhibits a transverse fracture (Figure 2.50). Gross callus formation is present, and is characterized by thick layers of lamellar bone covering the entire surface of the distal end. The fracture does not seem to have healed well due to the slight deformation of the bone, which has an inclination toward the medial aspect. The absence of a cloaca excludes the differential diagnosis of osteomyelitis. Three cases of fractures at the fifth metatarsal are reported: for Eleutherna a male individual, 35 years old (skeleton 001st), and another adult male (skeleton 009a) sustained transverse fractures on the left and right bones, respectively (Figure 2.51). The case from Kefali is a diagonal fracture sustained by an adult individual of unknown sex.

Figure 2.51 Eleutherna: Skeleton 009a, transverse fracture on the left fifth metatarsal (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

The ancient world was a difficult place to live and the Byzantine period was no exception; people must have been prone to accidents in daily life and have been victims of violent attacks. It is not surprising that Byzantine medical writers devoted entire chapters to the diagnosis and treatment of fractured bones, exhibiting great expertise in surgical operations (for example, amputations) when needed.[66]

The ability to detect which injuries occurred simultaneously is restricted in the case of multiple trauma observed in ancient populations, and these

66 See, e.g., *Paul of Aegina* (ed. Heiberg 1921 and 1924; tr. Adams 1834).

injuries may represent injury recidivism rather than a single traumatic episode. In modern clinical literature, injury recidivism refers to individuals who accumulate a number of traumatic lesions over their lifetime. Bioarchaeologists are currently applying the criteria developed by modern clinical researchers to determine whether characteristics of injury recidivism existed in past societies.[67] Although our cases of multiple fractures in the same individual may suggest an exceptionally dangerous life with repeated traumatic events, it seems unlikely that these individuals sustained constant physical abuse, since the observed fractures do not present different stages of healing. The advanced healing and, in some cases, secondary changes (for example, arthritic changes) indicate that the injuries occurred some years before the individuals' deaths, and were most likely associated with an accidental event. Such an interpretation appears even more plausible as the observed fractures provide no evidence that they resulted from an underlying disease. For example, the fractures of the lower radial shaft (Galleazi's fracture) and associated subluxation/dislocation of the distal radio-ulnar joint are typically produced by a fall on the hand with rotation force. Similarly, Colles' fracture is almost always due to a fall onto an outstretched hand.[68] Fractures of the clavicle – most commonly the middle segment – also usually result from a fall onto an outstretched hand or a fall on the shoulder. The high frequency of these fractures can be at least partially associated with the subcutaneous location of the bone.[69]

The possibility of injuries due to conflict must also be considered in some cases. Injuries most frequently associated with interpersonal violence and observable in archaeological remains include cranial injuries that can be attributed to direct blows,[70] multiple lesions from habitual or severe assault and distal ulna shaft fractures (parry fracture) resulting from defending a blow to the head.[71] The ulna parry fracture is perhaps the most controversial injury, owing to its implications for social behavior in past societies (interpersonal

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67 See, e.g., Judd 2002.

68 For a detailed paleopathological analysis and interpretation of Colles' fracture, see Mays 2006.

69 Resnick 1995, 2715–18.

70 See, e.g., Walker 1989; Powers 2005; Mays 2006; Torres-Rouff and Costa Junqueira 2006; Paine et al. 2007.

71 See, e.g., Walker 1989, 2001; Smith 1996; Bridges 1996; Anderson 1996; Hutchinson 1996; Jurmain and Bellifemine 1997; Jurmain 2001; Judd 2004; Powers 2005; Mays 2006; Torres-Rouff and Costa Junqueira 2006; Paine et al. 2007. According to Lovell 1997, 166, fractures of the skull (especially the nasal and zygomatic bones and the mandible), posterior rib fractures, vertebral spinous process fractures and fractures of the hand and foot bones, which can result from the direct trauma of punches and kicks, are considered to have a high specificity for a clinical diagnosis of assault.

violence, female abuse).[72] Judd, in her study on parry fractures, set a number of quantitative and qualitative criteria that could enhance the identification of the proximate mechanism of the fracture (direct or indirect force).[73] Nevertheless, any attempt to interpret such fractures as indications of interpersonal violence should be made with caution, as the interpretation affects how we perceive the familial, social and other relationships of a specific society. Limitations still remain in identifying the ultimate mechanism and the sequence of the healed injuries. It is, for example, impossible to know whether the individual acquired the injury during a fall caused by the individual's own clumsiness, an activity or a push during an altercation.

In the case of the cranial fracture of skeleton 002 from Kastella, the sharp, clearly defined edges could not have been produced postmortem in a dry skull. There is no evidence of remodeling or secondary infection. The individual does not seem to have survived long enough for the healing process to begin, thus the injury appears to have been perimortem. The sharp edge, as well as the lack of microfracture, is suggestive of a long, straight, sharp-edged weapon, such as a blade or sword.[74] The depressed fracture observed on the skull of skeleton 014 from Kastella is not typical of those from falls from high places, or those involving striking the head against a large mass, such as a rock or a hard surface, which would result in a large comminuted or linear fracture.[75] Most probably, this fracture pattern indicates a blow with a small weapon such as a sling-shot, small club or tool. Finally, in the paleopathological record fractures to the scapular body are relatively rare, most probably because this bone does not usually survive intact. Clinical cases of scapular fractures, also infrequent, demonstrate that the scapular body is mainly involved.[76] The type of fracture recorded for the scapula of skeleton 011a from Kastella can most probably also be attributed to a case of interpersonal violence – a direct force of considerable magnitude – where again a long, straight, sharp-edged weapon such as a blade or sword was used.

With the exception of the cranial trauma mentioned above, which was probably fatal, all the other fractures – albeit exhibiting complications (periosteal reaction, osteoarthritis, loss of normal shape of bone) and no evidence of medical treatment – demonstrate healing process, indicating that the individual survived the incident. It should be noted, though, that besides complications that should have affected the health status of the individual, the impact of each fracture and its sequelae upon lifestyle in general would have depended upon the range of

72 Grauer and Roberts 1996; Lovell 1997, 165; Jurmain 1999.
73 Judd 2008.
74 See the publication by Lewis 2008 on the identification of sword marks on bone.
75 Galloway 1999, 67–8.
76 Resnick 1995, 2718–20.

activities to which the individual was previously accustomed. Individuals whose lifestyles involved manual labor (for example, farming) would have found their activities significantly restrained by the type of injuries sustained, due to pain, weakness and reduced range of motion.

Humerus varus

Primary humerus varus is a rare condition.[77] It can occur due to trauma during birth, perhaps as a result of injury to the medial aspect of the growth plate.[78] The humeral shaft is where birth injury most often occurs. Displacement of either the humeral or femoral head is seldom found and is normally unilateral; bilateral involvement, if not due to intrauterine trauma, can occur if a child falls backward with arms extended and hands caught behind the buttocks.[79]

A young adult male from Eleutherna, approximately 19 years old (skeleton 001b), presents a distinctive pathological condition (0.3%). The head of the left humerus was displaced disto-medially, with resultant shortening of the anatomical neck that can be seen more clearly from the anterior aspect (Figure 2.52). There is no evidence of fracture and the metaphysis was not involved. The glenoid surface of the scapula is normal, but the acromion shows evidence of marginal osteophytosis and slight porosity. Because of the fragmentation of both humeri, measurements could not be taken. The preserved epiphyses of the other long bones were unaffected and no other pathological conditions are recorded. The appearance of this displacement is suggestive of unilateral slipped epiphysis, a well-known finding in the proximal femur.[80] The anomalous position of the humeral head, however, has led to a reduction in the angle of the neck, producing a so-called varus deformity, so that the term 'humerus varus' has been preferred.[81]

A variety of pathological conditions can produce humerus varus, among them osteomalacia and rickets, neonatal infection, tumor formation, thalassemia, cretinism and generalized spondyloepiphyseal dysplasia.[82] Skeleton 001b from Eleutherna shows no evidence of underlying disease or recent trauma; all other epiphyses present have developed and/or fused normally, and this isolated deformity does not correspond to any established syndrome. The condition appears to have been caused by untreated intrauterine or early childhood trauma, resulting in a deformity moderate to severe in degree, with impingement upon

77 Anderson 1997; Merbs and Vestergaard 1985; Capasso 1989.
78 Lucas and Gill 1947; Langenskiold 1953.
79 Tachdjian 1972.
80 Ortner and Putschar 1985.
81 Ogden, Weil and Hempton 1976.
82 Davies 1956; Ogden, Weil and Hempton 1976; Ellefsen et al. 1994.

Figure 2.52 Eleutherna: Skeleton 001b, displaced head of the left humerus (humerus varus) (photo: C. Bourbou)

the acromion.[83] Marked humerus varus frequently presents with symptoms during adolescence, and this 19-year-old individual from Eleutherna is likely to have lived with a slightly disabled shoulder and arm.[84]

Circulatory Disorders

A broad number of lesions can affect arteries and veins, and their etiologies range from infectious to autoimmune conditions. Most of the circulatory disturbances that affect the human skeleton occur in the long bones and can be associated with necrosis (cellular death), for example of the femoral neck, or with trauma and vascular deficiency.[85]

83 Bourbou 2001b.

84 Burman 1938; Davies 1956.

85 For a review of circulatory disorders, see Ortner 2003, 343–57.

Osteochondritis dissecans

Osteochondritis dissecans is a benign, non-inflammatory condition affecting young adults in which small, focal epiphyseal areas of necrosis appear on the convex surfaces of diarthrodial joints and result in the partial or complete detachment of a section of the subchondral bone and articular cartilage.[86] For the most part osteochondritis dissecans affects individuals between the ages of 10 and 25 years, with males affected two to three times more often than females. Any diarthrodial joint may be involved, but 85–90% of cases present in the medial femoral condyle; the remaining 10–15% have been found in the elbow (humeral condyle, radial head or coronoid fossa), tibial plateau, talus, hip joint (femoral head and/or acetabulum) and shoulder (glenoid cavity or humeral head).

Figure 2.53 Eleutherna: Skeleton 008b, osteochondritis dissecans (arrow) on the glenoid surface of the left scapula (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

Only one case of osteochondritis dissecans (0.3%) is observed in the skeletal samples studied here, on a 35-year-old male individual (skeleton 008b) from Eleutherna.[87] A porous, almost circular lesion is noted on the glenoid surface of

86 Aufderheide and Rodríguez-Martín 1998, 81–3; Ortner 2003, 351–2.

87 The diagnosis of this lesion is problematic and the data provided is usually ambiguous; therefore the single reported case probably significantly under-represents the actual frequency of the condition in Byzantine Crete. The sample from Stylos included four

the left scapula (Figure 2.53). The condition is regarded as idiopathic, since none of the suggested etiologies is sufficiently convincing: trauma or microtrauma, circulatory disturbances of the bone, inflammation, endocrine disturbances and genetic factors.[88] Familial incidence has recently been observed, which may be the consequence of a genetic predisposition.[89]

Congenital Abnormalities

A large number of congenital abnormalities can occur in the skeleton. Typically, these abnormalities are the result of a problem in embryological development; while some are incompatible with prolonged life, many are compatible with life and maturity.[90] The etiology of many of these abnormalities is poorly understood, but there is at least a strong probability that their pathogenesis involves a genetic predisposition (single gene disorders, chromosomal disorders or an interaction between genetic and environmental factors).

Spina bifida occulta

The condition is characterized by a failure of the vertebral neural arches, usually of the lower lumbar vertebrae, to fuse because of a neural tube defect. In spina bifida occulta the posterior parts of the vertebrae enclosing the spinal cord are absent; thus, in skeletal samples, the spinal canal is exposed, while in life it would have been bridged by cartilage or membrane.[91] The condition commonly involves one or more segments of the sacrum, but may occur in other parts of the spine.

The cases of spina bifida occulta in the adult sample are presented in Table 2.23. Five individuals (1.8%) presented spina bifida occulta; absolute frequency rate for the condition is 9.8% or five affected sacra of 51. For the skeleton 001h from Eleutherna, incomplete fusion of the posterior neural arch involved all sacral segments; two cases

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cases of pseudo-osteochondritis dissecans observed on the glenoid and tibial plateau of a female, 30–35 years old (skeleton 001), the glenoids of a 35-year-old male (skeleton 019), the glenoids and distal femoral ends of a mature male (skeleton 021) and the patella of a 51-year-old male (skeleton 022). Although the lesions resemble the circular porous lesions encountered in cases of osteochondritis dissecans, they actually represent taphonomic alterations on the bones' surface.

88 Helms 1989; Forrester and Brown 1990; Brower 1990; Kulund 1990; Bullough 1992; Martín-Oval and Rodríguez-Martín 1994.

89 Jaffe 1972.

90 See Barnes 1994, 1–31; Aufderheide and Rodríguez-Martín 1998, 51; Ortner 2003, 453; Roberts and Manchester 2005, 55.

91 Roberts and Manchester 2005, 55.

from Kefali involved all sacral segments as well; while, in the third case from Kefali, the neural arch is not completed at the fourth and fifth sacral vertebrae.

Table 2.23 Spina bifida occulta in the adult sample (individuals and/or sacra affected)

Site	Total no.	Affected	M	F	CPR%	Total no. of sacra	Sacra affected	TPR%
Eleutherna	100	1	1	0	1.0	35	1	2.8
Gortyn	29	1	1	0	3.4	4	1	25.0
Kefali	49	3	2	1	6.1	12	3	25.0
Total	*178*	*5*	*4*	*1*	*2.8*	*51*	*5*	*9.8*

M=Male, F=Female

Spina bifida occulta has often been diagnosed in archaeological populations and is known to have a genetic base.[92] Since it is found in adult skeletons from antiquity, the condition clearly did not cause its possessors difficulty in functioning satisfactorily. Today, spina bifida occulta is discovered only in the course of routine radiological examination.[93] It has been affirmed that when this defect is found in an adult individual from an archaeological context it can be assumed that the condition is spina bifida occulta, since the more severe form of the condition, spina bifida cystica, features a meningocele or a myelomeningocele that is accompanied by severe neurological problems that make long life unlikely.[94]

Sacralization

Shifting in the vertebral column is not rare, primarily at the less stable lumbosacral and occipitocervical borders. The affected vertebra (or transitional vertebra) takes on the characteristics of an adjacent vertebra. Such a shifting is possibly triggered by a delay in the formation of the intervertebral disc space and adjacent vertebral segments that border two regions of the vertebral column.[95] Sacralization refers to the complete or incomplete incorporation of the last lumbar vertebra into the sacrum, when shifting occurs on the superior part of the lumbosacral border.[96] It is more likely to occur unilaterally and more commonly on the right side, or

92 For cases in the paleopathological record, see Aufderheide and Rodríguez-Martín 1998, 62; Ortner 2003, 469.

93 Aufderheide and Rodríguez-Martín 1998, 61. The disorder is usually asymptomatic in the living individual.

94 Morse 1978.

95 Barnes 1994, 79–80.

96 Barnes 1994, 108–10.

asymmetrically. Symptoms include low back pain, severe pain radiating from the sacral area and down the leg and, since the condition causes curvature and rotation of the lumbar spine, it can lead to a progressive scoliosis.

Table 2.24 Sacralization in the adult sample (individuals and/or sacra affected)

Site	Total no.	Affected	M	F	CPR%	Total no. of sacra	Sacra affected	TPR%
Eleutherna	100	1	1	0	1.0	35	1	2.8
Kefali	49	1	1	0	2.0	12	1	8.3
Total	*149*	*2*	*2*	*0*	*1.3*	*47*	*2*	*4.2*

M=Male, F=Female

Table 2.24 presents the cases of sacralization in the adult sample. One individual from Eleutherna and one from Kefali (0.7%) present sacralization; absolute frequency rate for the condition is 4.2% or two affected sacra of 47. The fifth lumbar vertebra of skeleton 001st from Eleutherna (Figure 2.54) is fused with

Figure 2.54 Eleutherna: Skeleton 001st, fusion of the fifth lumbar vertebra with the first sacral vertebra (sacralization) (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

the first sacral vertebra. The sacralization is partial, involving only the right side of the sacrum. No detailed description of the defect is given for the Kefali case.

Tumors of Bone

Uncontrolled proliferation of bone, cartilage, fibrous tissue or blood vessels can generate tumors in bone. Benign tumors consist of well-differentiated, localized tissue, while malignant tumors consist of poorly differentiated tissue that continues to grow uncontrolled and potentially metastasizes to other parts of the body via the blood or lymphatic stream.[97] Malignant tumors affecting bone include carcinomas and sarcomas, either of which can spread from the primary site to other parts of the body (metastatic tumors). Bone sarcomas are rare but onset tends to be during young age, with the result that the prevalence between archaeological and modern skeletal samples is likely to be similar. Metastatic carcinoma to bone is much more common in archaeological human skeletal remains and, although the paleopathologist cannot perform the clinical test available to the modern pathologist, careful analysis of the type and distribution of lesions, age at death and sex of the skeleton facilitates the diagnosis.[98] In contrast, metastatic tumors of bone tend to be associated with old age, and their prevalence in ancient human populations is likely to be less than in modern western populations, as individuals in the past usually died of other causes before cancer could cause their death.[99] In our sample, only two cases of a benign primary osteoblastic tumor are observed.

Button osteoma

Button osteoma is a small, smooth lump of compact bone on the skull, and is one of the most common bone abnormalities encountered in both archaeological and modern populations. It consists of mostly dense lamellar bone and is usually located on the outer table of the cranial vault (mainly on the frontal and parietal bones). Usually the lesion is single, not more than 2 cm in maximal diameter, although multiple lesions can occur.[100] Eshed et al. proposed that what has been commonly described as 'button osteoma' in the anthropological literature is in

[97] Ortner 2003, 503.

[98] For a review of bone tumors, see, e.g., Dorfman and Czerniak 1998; Greenspan and Remagen 1998; Ortner 2003, 504–44. For cases in the paleopathological record of Greece, see Bourbou 2003b, 182–4.

[99] Ortner 2003, 504.

[100] Ortner 2003, 506.

fact not an osteoma, but rather a unique aberration, classified as hamartoma, so that the term 'button hamartoma' is suggested.[101]

Two button osteomas were recorded for the skull of a male individual (skeleton 015a) from Eleutherna (0.3%). One osteoma (1 × 1 cm) is located on the right frontal bone, while the other (0.5 × 1 cm) is located on the left parietal bone (Figure 2.55). Osteomas are predominantly asymptomatic, independent of sex and race, but age dependent.[102] Some researchers have suggested that these osteomas have neoplastic qualities.[103] Their etiology is unknown; theories invoke genetic, developmental, traumatic and infectious factors, although none of these have been verified.

Figure 2.55 Eleutherna: Skeleton 015a, button osteomas (arrows) on the frontal and parietal bones of the skull (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

101 Eshed et al. 2002.
102 Aufderheide and Rodríguez-Martín 1998, 375.
103 Perou 1964; Aufderheide and Rodríguez-Martín 1998.

Chapter 3

Tiny Occupants in Shallow Graves: The Bioarchaeology of Non-Adult Individuals

Childhood, whilst a biological stage of human development, is also a social construct. Many cultures have different attitudes towards the younger members of the population, and treat them differently in both life and death.[1] Children were once invisible in the archaeological record, but have come into view through an increase in relevant published material in recent years.[2] Researchers engaged in the study of children in the archaeological context often criticize archaeologists for tending to ignore children completely, or, when they are included in archaeological interpretations, for often depicting them in stereotypical ways that cast them in peripheral roles within the society. This point of view, that children are 'variables' rather than 'cultural actors,' appears to have stemmed from the notion that children were not really important because their activities did not make a significant contribution to the society and because, with the exception of mortuary evidence, their behavior left few material traces.[3] However, the application of gender-based approaches to archaeology has greatly enhanced our understanding of how families and societies were organized in the past, and children have emerged as making significant cultural contributions in areas considered important to archaeological research.[4] Whether researchers have diverse approaches for the inclusion of children and childhood in archaeological interpretations, or still struggle with how to identify their activities, the need to consider the biological and the cultural aspects of childhood is fundamental.

Survival of non-adult individuals is the most critical barometer of population fitness and biocultural changes within a society. However, it is only in the last decade that studies on growth and development, as well as on disease and

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1 For theoretical perspectives of childhood, see e.g., Scott 1999, 1–51; Sofaer Derevenski 2000, 3–16; Lewis 2007, 4–8.

2 Lillehammer 1989; Moore and Scott 1997; Kamp 2001; Dasen 2004; Bakke 2005; Baxter 2005a, 2005b; Wileman 2005.

3 Baxter 2005b.

4 Nelson 1997.

mortality patterns, have increased in number.[5] Earlier lack of studies has been merely explained by the repetitively cited argument that non-adult remains do not survive the burial environment. This argument is now proved to be ill-founded, as indicated by the large number of non-adult remains retrieved from archaeological excavations sometimes even better preserved than those of adults.[6] It is widely accepted, though, that non-adult remains are subject to factors inherent to the nature of their bones, burial conditions, excavation and recovery techniques, as well as social attitudes towards their disposal and associated funerary practices. Their porous bones are more susceptible to disarticulation, scavenging and color change; highly alkaline or acidic soils result in poor preservation; and lack of expertise on the part of the excavator to identify their tiny skeletal elements further hinders the optimal recovery of non-adult remains.[7] Another concern of bioarchaeologists stems from bias in the representativeness of the skeletal sample, as mortuary, cultural, economic and other variables influence the final resting place of the non-adults. In classical Greece, for example, the rites of passages in childhood were clearly defined, peaking with the formal recognition of the child as a full member of the society at the age of 3 years. Thus, children dying before that age may not have received a formal burial ritual, and may have been buried in different areas from the rest of the community.[8]

Besides these potential biases and although the debate on the 'gold standard' that 30% of the mortuary sample should contain non-adult individuals is still open to discussion, it is well understood that bioarchaeology can provide an important element to research on non-adult individuals in the past.[9] It is particularly the age at death of non-adults that potentially provides useful information on the population's ability to adapt to its environment, socio-economic transitions, cultural practices for feeding and weaning the infant, maternal health and obstetrics, as well as disease patterns. In the protected uterine environment the fetus receives essential nutrients from the mother and is protected from external

[5] For a thorough review on advances in children's bioarchaeology, see Lewis 2007, 10–13.

[6] See, e.g., Saunders 2000, 135–8.

[7] See, e.g., Gordon and Buikstra 1981; Herring, Saunders and Boyce 1994; Guy, Masset and Baud 1997; Jones and Ubelaker 2001; Robinson et al. 2003; Ingvarsson-Sundström 2003. The publication of specialized texts on fetal and juvenile anatomy see, e.g., Fazekas and Kósa 1978; Scheuer and Black 2000, 2004; Baker, Dupras and Tocheris 2005 facilitate the challenging task of identifying the morphologically complex non-adult skeletal parts.

[8] This topic currently stimulates new investigations; see, e.g., Lagia 2007; Bourbou and Themelis in press.

[9] Saunders and Barrans 1999; Saunders 2000; Perry 2005; Lewis 2007.

pathogens and other stimuli by her immune system. The response of the mother to a variety of environmentally and culturally induced stimuli indirectly affects the fetus. Neonatal deaths are attributed to the endogenous state of the infant, mainly genetic influences such as congenital abnormalities and the health status of the mother. Once born, it is the environment that has a direct effect on the child who is still protected, though for a short period, by breastfeeding. Postnatal deaths are considered to reflect the influence of the physical and cultural environment, such as poor sanitation and nutrition.[10] Any possible failure to adapt to this new environment has fatal effects. The ability of a population to provide the necessary biocultural means for a child's survival after birth is the most sensitive indicator of that population's overall fitness.

Children in Byzantine Society

The practical division of life in Byzantium into stages (educational periods and cultural transitions, such as marriage, entering civil or military service) is an inheritance from antiquity.[11] The classical Greek term *pais* was also broadly used by the Byzantines, along with *neogonon paidion* and *brephos* for the newborn, *nēpion* and *paidion* for the little child, *pais* and *teknon* for any child, boy or girl, *meirakion* for boy and *neaniskos* for young man.[12] In many cases, physiological age integrates with social age, and these two elements – the biological 'child data' and the sociocultural 'data child' – may be linked through careful consideration of how body changes in children correspond to alterations in their social and cultural identity.[13] Hence, children in every society can be manipulated to make statements, reflect cultural and religious beliefs, and affect existing ideological schemes, social concerns and political tensions; they can be given special associations with the rituals of life and death, embodying a number of contradictory forces which make them a powerful symbol within the human culture.

The role of beliefs, especially those connected with Christianity, is traceable on burial rituals, as non-adults are more likely to be found in communal

10 The implications of endogenous and exogenous causes of death in infants have been investigated in a study by Lewis and Gowland 2007, who compared infant mortality profiles from medieval and post-medieval rural and urban sites in England (AD 850–1859).

11 For the practical divisions of life in antiquity, see, e.g., Néraudau 1984, 47–9; Eyben 1993, 6–9.

12 Kiousopoulou 1997, 48, 53–4, 61–6; Hennessy 2008, 10–11; Prinzing 2009, 16–23.

13 Sofaer Derevenski 2000, 9–11.

cemeteries and burial grounds. Although, at least during the early Christian era, making clear-cut distinctions between pagan and Christian rituals is sometimes difficult, Lucy comments that:[14]

> It seems to be the general pattern that Christian cemeteries contain high proportions of younger burials, while pre-Christian sites can be typified by their general absence.

Detailed descriptions of the preparation of a child's body for burial and the relevant funerary ceremonies can be found in literary texts (cf. *Psellos'* oration on the death of his daughter Styliane), but when it comes to the actual procedure for the digging of graves for children, written texts remain silent and one can only turn to the archaeological evidence.[15] Segregation of non-adult burials within a Christian cemetery was not uncommon; however, child burials are usually found scattered among those of adult individuals. Burials in simple pits, cists or tile graves and in pottery vessels are usually encountered; non-adults are also recovered from ossuaries.[16] Commonly, non-adults were buried together with adult individuals: the pairing of mother and child, and two or more adult individuals and child are the most characteristic occurrences. Accompanying goods are also found within non-adult burials, such as jewelry (glass and bronze bracelets, necklaces, earrings) and toys.[17]

Christianity changed attitudes towards other practices such as contraception, abortion and infanticide, and already in the fourth century Christian writers condemned abortion and infanticide.[18] The Church not only condemned infanticide as a mortal sin but also developed a rite of exorcism to deal with human spirits which might be haunting the living. Valentinian I (AD 364–375) first made infanticide illegal in the western Roman Empire in AD 370 and later

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[14] Lucy 1994, 24–7. A good example is the late Roman infant cemetery at Lugnano, Italy, which is suggested to have resulted from a single outbreak of malaria: see Soren, Fenton and Birkby 1995; Soren 2008. The unusual pagan objects found scattered among the graves (e.g., headless puppies, a raven's claw) may reflect the desperation of people who were nominally Christians but who resorted to magical practices, including superstitious offerings, in moments of stress.

[15] *Psellos* (ed. Sathas 1876); Talbot 2009.

[16] Laskaris 2000, 288–290; Lewis 2007, 32–3; Tritsaroli and Valentin 2008.

[17] Koukoules 1948, 161–224; Rahmani 1981, Laskaris, 2000, 290; Lazos 2002, 57–84, 119–127; Pitarakis 2009; Anagnostakis and Lambropoulou 2009; examples of accompanying goods are illustrated in Papanikola-Bakirtzi 2002, 208, 419, 493–5.

[18] For a general discussion on abortion and contraception, see e.g., McLaren 1990; Riddle 1994; Talbot 1997, 125–6; McClanan 2002; Fulghum-Heintz 2003, 277; for a thorough overview on the bioarchaeology of infanticide, see Lewis 2007, 87–94.

Justinian (AD 527–565) recognized the fetus in the womb as a fully human being.[19] One of the best-known archaeological finds associated with infanticide is reported for the late Roman/early Byzantine site of Ashkelon in Israel.[20] The skeletal remains of nearly one hundred infants were found in the sewer beneath a bathhouse, suggesting a very abnormal attitude towards them, since all previous reports of the discovery of infant remains in Israel have described their careful burial. DNA analysis conducted at the Hebrew University resulted in the identification of a large number of males.[21] Textual evidence indicates that, although female infanticide was commonly practiced in ancient Roman society, female children were occasionally saved and raised to become prostitutes. The high number of dead male babies suggests that female infants were selectively preserved because they were of greater economic value. All these infants in the site of Ashkelon may have been offspring of prostitutes working in the bathhouse, which functioned as a brothel.

Research on Byzantine children is not entirely out of the realm of gender studies, but it has recently reached a greater level of sophistication, covering aspects such as social identity and legal status, education, material culture and influences of the cultural and religious environment.[22] However, it has been recently understood that the integration of biological data and documentary sources is the most holistic approach so to better perceive the life-course and the way in which Byzantine society treated its younger members.[23]

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19 *Codex Justinianus* (ed. Krueger and Mommsen 1928), IV.XLIII.1; see also Patlagean 1973, 85; Moffat 1986, 714–15; for the genesis of early Christian thought on the embryo, see Congourdeau 2004; Brisson, Congourdeau and Solère 2008.

20 Smith and Kahila 1992.

21 Faerman 1997. Infants thought to be the victims of infanticide have been occasionally tested using DNA sex typing; see, for example, Waldron, Taylor and Rudling 1999; Mays and Faerman 2001.

22 It is beyond the scope of this chapter to thoroughly explore the Byzantine literature referring to the life and role of children in Byzantine society. A number of publications cover some of these aspects; see, e.g., a broad overview of Byzantine childhood in Moffatt 1986; Papaconstantinou and Talbot 2009; on the legal status of children, Antoniadis-Bibicou 1973; Patlagean 1973; Beaucamp 1977; on children's education, Buckler 1948; Guilland 1953; Moffatt 1977; Kalogeras 2000, 2001; on the legal, ecclesiastical and monastic status of orphans, Miller 1996, 2003; on children and the Church, Leloir 1980; on the representation of children in Byzantine art, Antonopoulos 1986; Hennessy 2008.

23 Bourbou 2001a. In 2006 the Dumbarton Oaks Spring Symposium *Becoming Byzantine: Children and Childhood in Byzantium* tackled for the first time the subject in much more detail, also including papers on bioarchaeological evidence for the reconstruction of mortality profiles, Bourbou 2006c, and isotopic data for the detection of breastfeeding and weaning patterns, Bourbou and Garvie-Lok 2006. Byzantine children have recently drawn the attention of other researchers, see, e.g., Tritsaroli and Valentin 2008.

Byzantine children were expected to continue the family line, transmit family property from one generation to the other and care for their parents, assuring as well their burial and postmortem commemoration. As in every past or modern society worldwide, children must have been noisy, enjoyed playing and were prone to accidents, sometimes while performing household tasks.[24] Psellos' funeral oration, written in a quite different style from his other works, is a poignant example of emotions toward children, indicating that Byzantine parents expressed their love and grief in ways similar to our modern conceptions.[25]

Making It To Adulthood? Reconstructing Non-Adult Mortality Patterns

Pregnancy and delivery were thought by the Byzantines to be critical periods for both mother and child, since complications during pregnancy (for example, maternal illness, congenital abnormalities) or childbirth (for example, baby in breech position with its feet first) are frequently attested. Physiological problems or diseases that could interfere with a healthy pregnancy and birth were often thought to be the work of evil spirits, particularly the female demon Gylou. The demon was thought to appear to pregnant women and cause miscarriages, kill newborns because she was envious for not being able to have any children of her own, or was responsible for post-partum fever.[26] From the early Byzantine period, bronze or lead amulets depict a half-woman, half-serpent figure with disheveled hair being speared by a rider saint, the so-called Holy Rider.[27] Similarly, on the reverse of some of the Holy Rider amulets appears the depiction of various animals attacking the so-called 'Evil Eye' or the 'Evil Eye of Envy', which is connected to the notion that envy could inflict harm. Parents may have put the Holy Rider/Evil Eye amulet on a newborn or hung it near the baby's cradle.[28]

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[24] Byzantine literature includes numerous accounts of accidents; Moffatt 1986, 707 refers to children falling down wells, falling off buildings, cracking their heads on rocks; Abrahamse 1979, 506–7 notes falls into boiling cauldrons, pits and cisterns, eating eggs of serpents, crawling to the edge of windows; see also examples in, e.g., the *Vita of Symeon Stylites the Younger* (ed. van de Ven 1962), chs 149, 196, 238.

[25] See Patlagean 1996, 487–8.

[26] Gylou was based on a prototype of Lilith, the barren first wife of Adam in the Jewish tradition, and on baby-snatching nymphs from ancient Greek lore; see Greenfield 1988, 182–90; Hurwitz 1992, 90, 96; Fulghum-Heintz 2003, 278–80.

[27] See Vikan 1984; Russell 1995.

[28] On the attitude of the Church towards such popular notions, see Dickie 1995. Besides taking these anti-demonic measures, women also appealed to the Virgin Mary and

Byzantine illustrations of childbirth depict the young mother against an architectural background, dressed in a short, lightweight tunic, drawn above the knees, free of the usual constraining band for the breasts and with disheveled hair, giving birth in seated and standing positions, lying on a bed or using a birthing chair.[29] Koukoules indicates another method with the woman on her knees, as recommended by the second-century AD physician Soranus, especially when the woman suffered from degeneration in the lumbar region.[30] Although these images usually represent the birth of holy figures, they can be seen as depicting the everyday reality of such an event, since the artists must have drawn upon the world around them for inspiration. No evidence exists that Byzantine surgeons performed Caesarean sections, but their excellent surgical skills are evidenced in operations such as embryotomy (physical dismemberment and removal of the fetus from the uterus) or the separation of Siamese twins as early as the tenth century AD.[31] Gynecology does not seem to have made great advances in the Byzantine era, and, in many medical texts from the period, specifically female concerns are beclouded or even omitted.[32] The relationship between menstruation, conception and the uterus was not fully understood by the Byzantines. The womb was considered as an enigmatic organ or as the cause of pathological conditions (for example, migraines and erratic behavior) and was assigned almost magical powers.[33] Several surviving amulets depict the 'wandering womb' as an octopus-like creature with a female face and include specific inscriptions, or the Holy Rider motif, emphasizing the connection between the womb and the risks of childbirth.[34] Male doctors

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saints such as Hagia Marina for help during childbirth, see Fulghum-Heintz, 2003, 276, 279–80.

[29] Koukoules 1951, 22–3; Talbot 1997, 124–5; Meyer 2005, 312–13; cf. the manuscript illustrations of Rachel giving birth to Benjamin (Vatican City, Vatican Library, *gr*. 747, fol. 56v); Lot's daughter bearing Ben-Ammi (Vatican City, Vatican Library, *gr*. 746, fol. 77v); Rebecca giving birth to Esau and Jacob (Vatican City, Vatican Library, *gr*. 747, fol. 46v).

[30] Koukoules 1951, 23.

[31] Examples of tools used for embryotomy (e.g., pierlike carnioclasts and embryo hooks) were excavated at Ephesus and probably date to the fifth century; see Bliquez 1984; McClanan 2002. Pentogalos and Lascaratos 1984, and Matsaggas and Marketos 1985 brought to attention the case of the Siamese twins.

[32] Certainly, a number of Byzantine physicians refer in their works to specific diseases suffered by women (tumors, menstruation problems, inflammations etc); see discussion in, e.g., Ricci 1950; Harstad 1986.

[33] Aubert 1989.

[34] Metal amulets, the cheapest being of bronze, as well as semi-precious stones such as hematite, commonly known as 'bloodstone' for its red color and thought to aid in stopping

who had the formal education to deal with gynaecological issues often did not examine women patients, leaving their examination to midwives or the patients themselves.[35]

Evidence of high infant and childhood mortality is often attested in the Byzantine sources. The following examples – to give but a few – are derived from hagiography of the ninth century. In the Vita of St Evaristos mention is made of an unfortunate father who has lost four children in a row at birth; the Vita of St Peter of Atroa speaks of a couple whose 13 children all died prematurely; the Vita of Theodora of Thessalonike refers to Theodotos, a benefactor of Theodora's monastery, who saw four of his children die young.[36] Besides these anecdotal indications of high non-adult mortality in hagiography, the studies based on documentary evidence by Patlagean and Laiou, although looking at a specific area and time period, give an indication of what we might generally expect on non-adult mortality patterns.[37] Patlagean surveyed grave stelae of children from fourth-century Asia Minor and the area between Egypt and Syro-Palastine and found that only 50% of the children survived to the age of 15 years. Laiou examined census records concerning fourteenth-century Macedonian peasants living on monastic lands and found that half of the children died before the age of 5 years.[38] If we turn to the bioarchaeological record for early and middle Byzantine Crete, the non-adult sample under study includes 174 individuals, representing 39.1% of the total number of individuals under study. The distribution of non-adult deaths by age group is presented in Figure 3.1. Non-adults up to 1 year of age include 37 individuals (21.2%), while a clustering of deaths is observed for children aged 1 to 14.6 years, with 99 individuals (56.8%); the number of deaths for adolescents aged 14.6 to 17 years decreases to 24 individuals (13.7%). Comparing time periods, non-adults up to 1 year of age include 24 individuals

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hemorrhage, are known; see Hanson 1995; Fulghum-Heintz 2003.

35 For a presentation of the manual of gynecology transmitted under the name of Metrodora (who has been traditionally considered as living in the seventh century AD), see Congourdeau, 1993b; for its analysis as an *iatrosophion*, see Touwaide 2006; for female physicians and midwives see, e.g., Kislinger 1989; Bourdara 1989; Margarou 2000, 223–6, 235–6; Nikolaou 2005, 286–329; Fulghum-Heintz 2003, 139–40.

36 *Vita of Saint Evaristos* (van de Vorst 1923), p. 317, ch. 34; *Vita of Saint Peter of Atroa* (ed. Laurent 1956), ch. 59; *Vita of Theodora of Thessalonike* (ed. Paschalides 1991), ch. 8–9, 78–84, and the English translation by Talbot 1996, 228–30. It is noteworthy that a common *topos* of hagiography is for parents to dedicate to monastic life a child who manages to survive after siblings born earlier have all died. In the case of the couple who have lost all of their 13 children, their fourteenth child who survived became a monk; similarly, the fifth child of Theodotos, a girl who miraculously recovered, was raised in Theodora's nunnery.

37 Laiou 1977; Patlagean 1977.

38 On life expectancy estimations, see Laiou 1977, 293–4; Patlagean 1977, 95–100.

(17.9%) and 13 individuals (32.5%) for the early and middle Byzantine period respectively. The next age category includes 79 children (58.9%) for the early Byzantine period and 20 (50.0%) for the middle Byzantine period. Deaths of adolescents count for 17 individuals (12.6%) for the early Byzantine period and seven (17.5%) for the middle Byzantine period (Figure 3.2).

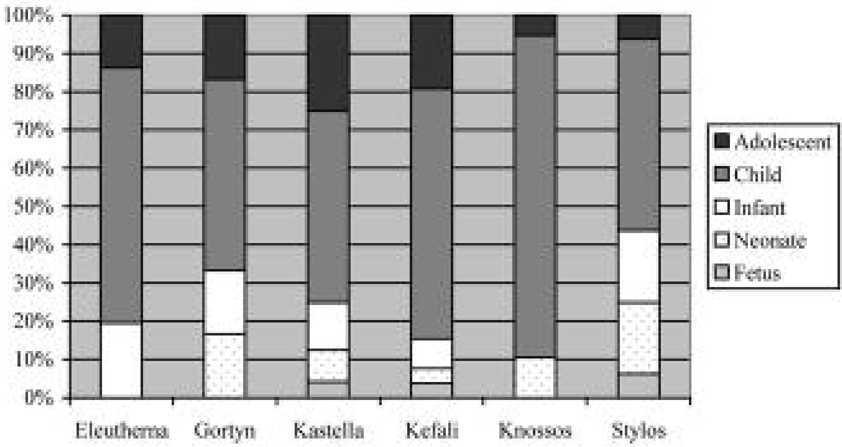

Figure 3.1 Non-adult mortality in the sample

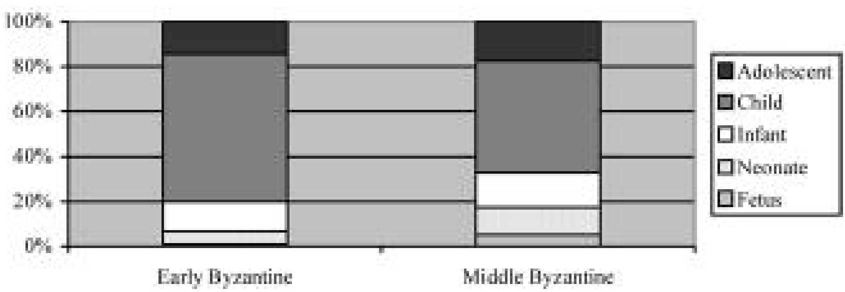

Figure 3.2 Non-adult mortality by time period

It is commonly expected that in any mortality sample the highest proportion of deaths will be among infants. Infant mortality is calculated as the number of infant deaths in one calendar year per 1,000 live births.[39] Modern data derived from the World Health Organization (WHO) suggest that infant mortality, especially during the first four weeks after birth, is still a major problem for

39 Stockwell 1993.

developing countries, as in Africa, for example, where there are 41 deaths per 1,000 live births. Overall, in developing regions the risk of death is more than six times that of developed countries, while in the least developed regions it is more than eight times higher.[40]

As argued above, early deaths are generally attributed to the endogenous state of the infant and the health status of the mother. A number of factors could have affected both the mother and the fetus during pregnancy and at the time of and after delivery. Poor maternal health and nutritional status, inadequate care during pregnancy and possibly restricted access to medical treatment, inappropriate management of complications during pregnancy and delivery (for example, infection, hemorrhage, eclampsia, obstructed labor, fetal malpresentation), poor hygiene during delivery and the first critical hours after birth all could have played their part. On the other hand, problems such as a premature birth, difficulties in adapting to extrauterine life, harmful practices after birth that lead to infections (for example, neonatal tetanus) and general lack of newborn care may result in the death of the fetus or the newborn.[41] Sudden Infant Death Syndrome (SIDS) may also have played a role in infant mortality patterns in past populations, as most deaths peak at the age of 2 to 3 months.[42] SIDS cannot be excluded as a possible explanation of infant deaths in archaeological populations, as people in the past described sudden unexplained infant deaths similar to the typical SIDS death today.[43]

Once past the crucial period of infancy, children were generally at risk of death due to weaning, exposure to infectious disease and susceptibility to accidental trauma. In the majority of the sites, and independent of the time period, child mortality exceeded infant mortality (see Figure 3.2). This clustering of child deaths could be rooted largely in environmental factors, such as poor sanitation, and cultural factors influencing weaning practices.[44] If living conditions were harsh and unhygienic, any child could have been at risk, especially one who had already caught their share of early childhood illnesses. Weaning practices and the transition from breastmilk to solid foods exposed the child to an increased number of bacterial and parasitic infections, giving rise to the weanling diarrhea

40 WHO 2006, 19.

41 See relevant discussion in Barker and Osmond 1986; Barker 1992a, 1992b; Barker and Martyn 1992; Lewis 2007, 84–6. Neonatal tetanus has been, and remains, a common cause of infant death, particularly in environments where lack of hygiene at birth is prevalent, see WHO 2006, 3.

42 Bourbou 2004, 68.

43 Savitt 1993. For the contribution of anthropological studies to SIDS, see the study by McKenna, Ball and Gettler 2007.

44 Bourbou 2004, 66–7; Lewis 2007, 99–100; see also Chapter 4.

complex.[45] The nutritional value of supplementary foods, sanitary conditions in which feeding took place and the overall state of the child's environment were of vital importance. Malnourished children are more susceptible to infections and, as nutritional stress results in children being less resilient to future infections, successive cycles of infection and malnutrition take place.

Non-Adult Health and Disease Patterns

Although pediatrics in the modern sense did not develop as a separate specialty in Byzantine medicine, Byzantine physicians included in their medical texts sections devoted to perinatal care and nutrition, as well as descriptions and treatments of specific pathological conditions.[46] For example, Oribasius, Aetius of Amida and Paul of Aegina devoted specific sections in their books to the care and feeding of the newborn and the selection of a wet nurse, as well as to the treatment of various common diseases suffered by children, such as aphthae, inflammations of the ear and eyes, cough and congenital abnormalities (for example, hydrocephalus) or health problems during dental eruption.[47] *Vitae* of saints also provide useful information on pathological conditions, as, for example, the case of a crippled boy who could only crawl on all fours, supporting his hands on wooden blocks.[48] A number of specific childhood diseases such as smallpox, measles and scarlet fever would often kill the individual before any skeletal changes could develop. Our knowledge of this type of fatal disease is enriched when studying the literary sources. For example, Michael Psellos describes the fatal disease that afflicted his beloved daughter Styliane, possibly referring to a case of smallpox.[49]

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[45] Lewis 2007, 99–100.

[46] For an overview of pediatrics in Byzantium, see Poulakou-Rebelakou 1992. Documentary evidence on perinatal nutrition and the introduction of supplementary foods following cessation of breastfeeding are discussed in Chapter 4.

[47] See, e.g., *Oribasius* (Raeder 1928–33), V; *Aetius of Amida* (Olivieri 1935), IV; *Paul of Aegina* (ed. Heiberg 1921 and 1924; tr. Adams 1834), I. The most detailed study on childhood illness found in the Byzantine medical texts is the book by Hummel 1999.

[48] *Vita of Makarios of Pelekete* (ed. van den Gheyn 1897), 149–50.

[49] This case, as well another possible one attested by Theodorus Prodromus (AD 1100–1170), was brought to scholarly attention by Lascaratos and Tsiamis 2002; see also Leven 1993, 1997. When bone lesions have not developed due to the acute death of the individual, preserved soft tissues of mummified children provide an excellent source for studying the presence and development of childhood diseases, such as smallpox. One case of a 2-year-old child from mid-sixteenth century Italy presenting the exanthema typical of smallpox is reported by Fornaciari and Marchetti 1986. For a brief overview on the

The types of paleopathological data that can be obtained from non-adult remains are both indirect and direct. For example, indirect evidence on obstetric hazards can be retrieved from the presence of fetuses within or expelled from the abdominal cavity of a female.[50] Similarly, a number of lesions present in the teeth and bones of non-adults have been used as indirect evidence for malnutrition (non-specific metabolic stress), such as enamel hypoplasia, cribra orbitalia and porotic hyperostosis. Direct evidence on specific deficiency diseases is provided in cases of scurvy and rickets, while fracture patterns may help identify child abuse, accidental injuries or suggest the type and onset of labor in which non-adults were engaged. The vast majority of pathological conditions that can be detected in the adult skeleton can be also observed on non-adult remains, such as dental diseases, specific infections, neoplasms and metabolic and congenital conditions – to name but a few.[51]

However, the fact that not all diseases leave traces on skeletal remains, coupled with factors associated with the nature, development and preservation of immature bones, limits the diagnosis of pathological conditions in non-adults. Problems also exist regarding the diagnosis and etiology of diseases, leading researchers in some cases to exclude specific age categories from their investigation.[52] Current improved methods and application of innovative techniques facilitate the diagnosis of specific pathological conditions such as scurvy and rickets.[53] The detailed study by Lewis on the nature, distribution

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pathological conditions observed in child mummies, see Bourbou 2005, 210; Atoche-Peña, Rodríguez-Martin and Ramírez-Rodríguez 2008, 555–83.

50 See Malgosa et al. 2004.

51 See, e.g., on rickets: Ortner and Mays 1998; Mays, Brickley and Ives 2006; Blondiaux et al. 2002; on enamel hypoplasia, Boldsen 2007; on leprosy, Bennike et al. 2005; on yaws, Buckley and Tayles 2003; on osteomyelitis, Canci, Tarli and Repetto 1991; on congenital syphilis, Palfi et al. 1992; Ferencz and Józsa 1992; Gladykowska-Rzeczycka and Krenz 1995; Rothschild and Rothschild 1997; Erdal 2006; on neoplastic conditions, Barnes and Ortner 1997; Alt et al. 2002; Anderson 2002; on Binder syndrome, Mulhern 2002; on dwarfism, Tillier et al. 2001; on tuberculosis, Ortner and Bush 1993; Schultz 1999; Santos and Roberts 2001; on trauma, Jiménez-Brobeil, Al Oumaoui and du Souich 2007. For comparative studies on non-adult health patterns, see, e.g., Buckley 2000; Lewis 2002; Blom et al. 2005; Bennike et al. 2005; Boldsen 2007; Schultz, Timme and Schmidt-Schultz 2007.

52 Ribot and Roberts 1996, excluded non-adults under the age of two when recording the presence of periostitis in their samples, arguing that it is almost impossible to distinguish between normal and abnormal bone porosity in infants and children, as skeletal growth is very intensive during uterine life and the first two years of life.

53 See, for example, the study by Mays, Brickley and Ives 2006, and Brickley and Ives 2008 on dry-bone criteria for recognition of rickets in non-adults remains, and the studies by Ortner et al. 2001, Brickley and Ives 2006, 2008 on the diagnosis of skeletal lesions attributed

pattern and possible etiology of endocranial lesions provides a solid background for the recording and interpretation of these lesions.[54] Solving the problems of preservation and diagnosis inherent to the study of non-adult remains is fundamental for answering broader questions about health and disease patterns at a wider regional and temporal level.

The pathological conditions observed in our non-adult sample have been carefully evaluated. Pathological conditions for which only vague or inadequate reference exists were excluded. For example, Zygouri refers to a fracture at the distal end of the left fibula of a juvenile (ΚΠα 18-08), 16 to 18 years of age from Kefali, simply arguing that the fracture is well healed; however, no further evidence on the type of fracture is provided, nor was the bone radiographed.[55] Similarly, Musgrave refers to a case of a 10-year-old child suffering from dysplasia on the left femur, with no further description of the case or possible complications. He also argues the presence of 'a great number of Harris lines', as revealed by the radiographic analysis of non-adult long bones, suggesting that their presence can be attributed to metabolic disturbances during growth caused by diseases or malnutrition.[56]

A small number of dental diseases, including a few cases of dental enamel hypoplasias, are recorded for the samples of Gortyn, Kastella and Kefali. Mallegni reports one case of an adolescent exhibiting abscess and ante-mortem tooth loss;[57] Zygouri has observed a carious lesion and periodontal disease in a 5-year-old child, as well as a carious lesion and calculus in an adolescent; calculus is also present in a child and an adolescent from Kefali and in a child from Kastella.[58] Such a small number of cases contribute little to the reconstruction of dental disease patterns in our non-adult sample. However, the appearance of dental pathologies in childhood probably indicates that diet and lack of systematic oral hygiene could have stimulated an early onset. Dental enamel hypoplasias are recorded in the form of striae, mainly on the canines and incisors, in three children from Kastella, and in one adolescent from Kefali. Although dental enamel hypoplasias have long been used as a non-specific indicator of systematic physiological stress during early life, the number of cases is too small to infer possible patterns linking these defects to bouts of malnutrition, weaning, disease,

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to scurvy. The application of innovative techniques such as paleohistology enhances a more positive diagnosis; see Schultz 2001.

54 Lewis 2004.

55 Zygouri 2005.

56 Musgrave 1976; for a review on Harris lines, see Aufderheide and Rodríguez-Martin 1998, 422; Lewis 2007, 107–11.

57 Mallegni 1988, tables 1 and 2.

58 Zygouri 2005 refers to another two 'subadults' exhibiting dental pathologies.

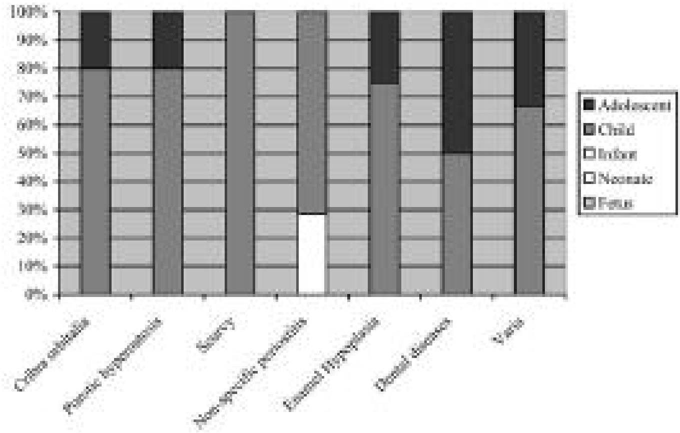

Figure 3.3 Distribution of pathological conditions in the non-adult sample (individuals affected)

Under "Varia" are included: a case of fracture, infantile cortical hyperostosis and a congenital abnormality (femur dysplasia)

fever or intrauterine under-nutrition due to a deficient maternal diet.[59] It is worth noting, however, that recent studies have discredited much of the earlier work that correlates peaks in enamel hypoplasias with weaning stress, arguing that, during the two- to four-year developmental period (frequent peak in the formation of these defects), the enamel is more susceptible to environmental disturbance and that the position of the defects on the tooth crowns may be related to the structure of the enamel layers.[60]

Based on this survey of the pathological conditions in the non-adult sample, our discussion will be limited to the presence of cribra orbitalia and porotic hyperostosis, scurvy, non-specific periostitis and infantile cortical hyperostosis. Figure 3.3 presents the distribution of pathological conditions by age group. From birth to 1 year of age, two individuals (1.1%) demonstrate pathological conditions, while the majority of cases are children, including 26 individuals (14.9%); adolescents number seven individuals (4.0%). Comparing time periods, the breakdown by age categories includes from birth to 1 year of age one individual (2.2%), 20 children (12.6%) and seven adolescents (3.7%) for the early Byzantine period; for the middle Byzantine period only one infant and one adolescent (2.5%) respectively, and seven children (12.5%) are included (Figure 3.4).

[59] See, e.g., Goodman and Rose 1990; Guatelli-Steinberg and Lukacs 1999; King, Humphrey and Hillson 2005; Ogden, Pinhasi and White 2007; Triantaphyllou et al. 2008; see relevant discussion in Lewis 2007, 104–7, and Chapter 2 in this book.

[60] See, e.g., Reid and Dean 2000.

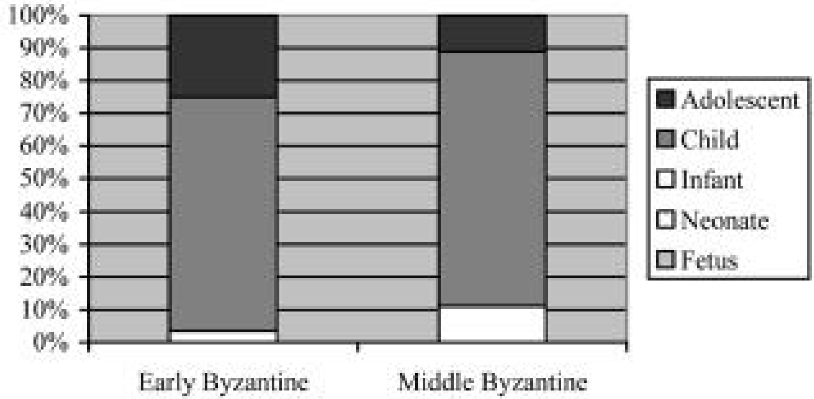

Figure 3.4 Distribution of non-adult pathological conditions by time period (individuals affected)

Hematopoietic and Metabolic Disorders

Cribra orbitalia and porotic hyperostosis

Cribra orbitalia and porotic hyperostosis are the most frequently observed hematopoietic disorders in the non-adult sample (Figure 3.5).[61] The observed cases of cribra orbitalia and porotic hyperostosis are presented in Tables 3.1 and 3.2. Ten non-adult individuals (5.7%) exhibited cribra orbitalia and five (2.8%) exhibited porotic hyperostosis. Absolute frequency rate for cribra orbitalia is 85.0% or 17 affected orbital roofs of 20, and for porotic hyperostosis 15.5% or 12 affected cranial bones of 77. When comparing time periods, cribra orbitalia is observed in ten individuals or 5.7% for the early Byzantine period, while no cases are reported for the middle Byzantine period. Porotic hyperostosis is observed in three individuals (2.2%) for the early Byzantine period, while one individual (2.5%) from the middle Byzantine period exhibits porotic lesions on the cranial vault. Absolute frequency rate can be provided only for the early Byzantine period, where for cribra orbitalia it is 85.0% or 17 affected orbital roofs of 20. Absolute frequency rate for porotic hyperostosis is 15.3% or ten cranial bones of 65 for the early Byzantine sites, and 16.6% or two bones of 12 for the middle Byzantine sites.

61 For a thorough discussion on cribra orbitalia and porotic hyperostosis, see Chapter 2.

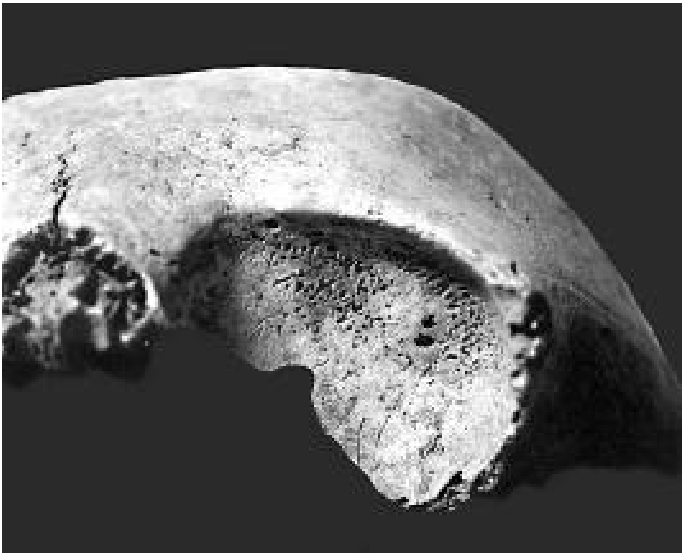

Figure 3.5 Eleutherna: Skeleton 005ie, cribra orbitalia (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

We noted in Chapter 2 that differential diagnosis of porous lesions is a challenging task, as a variety of conditions may result in similar lesions. However, the anatomical details of the lesions observed in the sample cannot be attributed to infectious conditions or metabolic disorders such as scurvy or rickets.[62] Similarly, the lack of skeletal evidence for genetic anemias excludes this diagnostic option. It seems better to suggest a multifactorial etiology involving the synergistic effects of dietary deficiencies, infections and parasite load, which potentially resulted in marrow hyperplasia in response to anemia. However, if these lesions can be attributed to an anemic reaction, this does not necessarily have to be exclusively attributed to an iron deficiency. In the paper by Fairgrieve and Molto, feeding practices and the quality of supplementary foods introduced after cessation of breastfeeding are considered for the interpretation of cribra orbitalia recorded in the non-adult sample.[63] The authors argue that the introduction of both goat's milk and honey in the infant diet may have had dire consequences, as infants fed on goat's milk develop megaloblastic anemia at about 3–5 months due to folic acid deficiency. Honey, on the other hand, is

62 See Ortner 2003, 375.
63 Fairgrieve and Molto 2000.

a confirmed source of *Clostridium botulinum* spores, resulting in a severe and often fatal form of food poisoning – botulism.[64] As porotic lesions are observed primarily in children (see Figure 3.5), weaning stress must be considered as a plausible explanation for their development.

Table 3.1 Cribra orbitalia and porotic hyperostosis in the non-adult sample (individuals affected)

Site	Total no.	Affected with cribra orbitalia	CPR%	Affected with porotic hyperostosis	CPR%
Eleutherna	51	3	5.8	0	0
Gortyn	24	3	12.5	0	0
Kefali	40	4	10.0	4	10.0
Stylos	16	0	0	1	6.2
Total	*131*	*10*	*7.6*	*5*	*3.8*

Table 3.2 Cribra orbitalia and porotic hyperostosis in the non-adult sample (bones affected)

Site	Total cranial bones	Cranial bones affected	TPR%
Orbits			
Eleutherna	14	5	35.7
Gortyn	-	6	-
Kefali	6	6	100
Total (orbits)	*20*	*17*	*85.0*
Frontal			
Kefali	22	2	9.0
Parietal			
Kefali	25	4	16.0
Stylos	12	2	16.6
Total (parietal)	*37*	*6*	*16.2*
Temporal			
Kefali	18	4	22.2
Total	*97*	*29*	*15.5*

Vitamin C Deficiency (Scurvy)

Scurvy is a dietary deficiency of ascorbic acid (vitamin C). The vitamin is found in a wide range of foods, including numerous vegetables (dark-green leafy vegetables contain 100–150 mg/100 g) and fresh fruits (oranges and lemons contain 50 mg/100 g); small amounts of vitamin C are also available from milk (goat/sheep milk contains 2–3 mg/100 g), organ meat (liver and kidney

64 See also Chapter 4.

contains 10–40 mg/100 g) and fish (cod flesh contains 0.5–2 mg/100 g).[65] It is not required in the diet of most animal species; only humans and a few other species, such as guinea pigs, lack the enzyme necessary to synthesize the vitamin.[66] Vitamin C has a number of roles in the body, including the formation of collagen and cartine synthesis, which is required to produce energy in muscles, blood formation and the metabolism of iron and folate.[67]

Rapidly growing bones – such as the costochondral junctions of ribs, the distal metaphysis of the femur, radius and ulna and the proximal epiphysis of the humerus – demonstrate the most marked skeletal changes. The onset of scurvy results in defective connective tissue and blood vessels, making scorbutic infants and children particularly vulnerable to hemorrhage. Skeletal changes are caused either directly by the vitamin C deficiency or by traumatic effects on the scorbutic bone and associated blood vessels. The condition is rarely observed before 4 months of age, with a peak between 8 and 10 months.[68]

Infantile scurvy has until recently received little attention in the paleopathological record.[69] There may have been problems in recognizing the condition as a distinct clinical entity, and perhaps many cases of scurvy may have been misdiagnosed.[70] Recent advances in the identification of scorbutic skeletal lesions as discussed by a number of researchers enhance the ability to positively recognize the changes attributed to the condition.[71] Table 3.3 presents the macroscopic and radiological features required for the diagnosis of scurvy. Furthermore, the application of innovative techniques such as paleohistological analysis enables researchers to differentiate scorbutic cases from other hemorrhage-inducing pathologies like inflammation and anemia. [72]

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65 Vitamin C contents following data given in Brickley and Ives 2008, table 4.1; WHO 1999, table G.

66 Hodges 1980.

67 Brickley and Ives 2006, 2008, 47.

68 Ortner 2003, 384.

69 For an early description of scurvy, see Barlow 1883; Fraenkel 1929. Up-to-date paleopathological cases are reported by Ortner 1984; Roberts 1987; Molleson and Cox 1993; Lilley et al. 1994; Mogle and Zias 1995; Ortner and Ericksen 1997; Ortner, Kimmerle and Diez 1999; Ortner et al. 2001; Bourbou 2003c; Melikian and Waldron 2003; Maat 2004; Brickley and Ives 2006; Garvie-Lok 2008; Mays 2008; see also a thorough overview of cases in the paleopathological record by Ortner 2003, 387–93 and Brickley and Ives 2008, 54–6, table A1.

70 Stuart-Macadam 1989.

71 Ortner and Ericksen 1997; Ortner, Kimmerle and Diez 1999, Ortner et al. 2001; Lewis 2004; Brickley and Ives 2006, 2008; Melikian and Waldron 2003.

72 Schultz 1989; Carli-Thiele 1995. On histological features of scurvy in non-adults, see Brickley and Ives 2008, 65–7, table 4.6.

Table 3.3 Macroscopic and radiological features required for a diagnosis of scurvy in non-adults

Bones affected	Macroscopic features	Radiological features
Cranium	Abnormal porosity (sphenoid, mandible, maxilla and orbits) New bone formation (orbits and vault)	
Ribs	Fracture of bone adjacent to costochondral junction Enlargement of ribs adjacent to costochondral junction (scorbutic rosary)	
Scapulae	Abnormal porosity of cortex (supraspinous and infraspinous areas)	
Long bones	New bone formation (commonly towards ends)	Irregularity and thinning of the cortex White line of Frankel or dense metaphyseal line Radiolucent or 'scurvy' line Wimberger ring Corner fractures or sign

Modified after Brickley and Ives 2008, tables 4.2 and 4.4

Two non-adult individuals (005ie and 004e) from Eleutherna exhibit skeletal lesions suggestive of scurvy.[73] The distribution of lesions in skeleton 005ie is presented in Figure 3.6. Pathological bone changes of skeleton 005ie (4 years ± 12 months) consisted of subperiosteal new bone formation in an irregular and extensive woven pattern on the orbital roofs, mainly in the anterior areas (Figure 3.7). The lesion in the right orbit is more extensive and thicker. New bone formation extends above the supraorbital ridges on both the external (2.3 × 1.7 cm) and internal (3 × 2.4 cm) surfaces of the frontal bone. Fragments of the temporal and occipital bones exhibit similar porous activity on the external surfaces. Porous activity is also visible along the medial surface of the coronoid process of the right mandible. The metaphysis of the left tibia exhibits a hematoma, subperiosteal organized, possibly of traumatic origin (Figure 3.8). Skeleton 004e, a child (4–12 years), exhibits woven bone reaction on both mandibular rami and on the occipital bone, extending onto the superior nuchal lines (Figure 3.9).

73 Bourbou 2003c, 2004, 55–6.

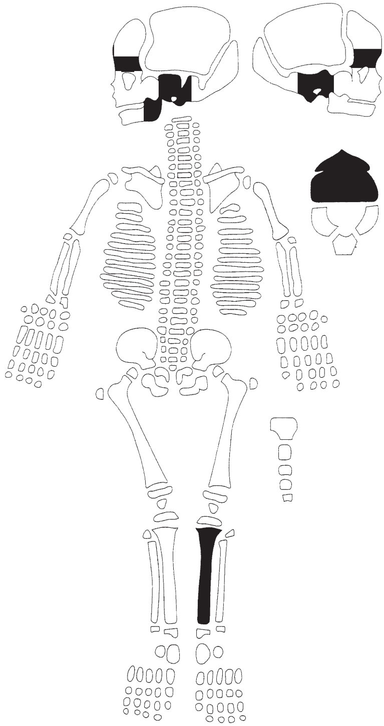

Figure 3.6 Diagram of skeleton 005ie, from Eleutherna. In black color are indicated the areas exhibiting lesions associated with scurvy

Chronic bleeding and subsequent ossification at multiple sites on the skull are associated with scurvy and are the most likely reason for the observed bone lesions, although the fragmentation of the skulls of the skeletons from Eleutherna does not allow a thorough study of the anatomical sites associated with scorbutic lesions. The mandible of skeleton 005ie is fragmentary, but evidence for abnormal porosity is present on the medial surface of the coronoid process of the mandible, where the temporalis muscle attaches. The bone reaction seen on the mandible of this individual is compatible with the type of inflammatory lesions that can occur as a result of hemorrhage induced by the stress of chewing, since the temporalis muscle is important for chewing. Regarding the hematoma, presumably of traumatic origin, observed on the tibia of skeleton 005ie, infractions (incomplete fractures) with subperiosteal hematoma are for the most part found in areas subjected to stress by the body's own weight, particularly the joints and metaphyses of the long bones of the leg, especially the femur and

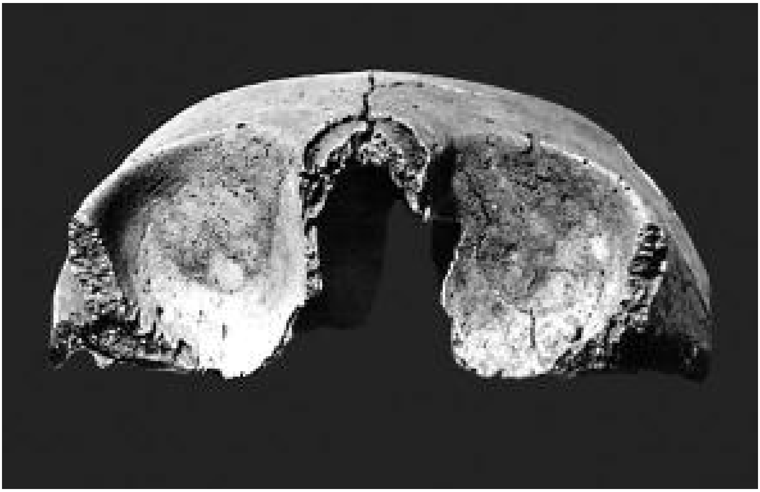

Figure 3.7 Eleutherna: Skeleton 005ie, orbital lesions associated with scurvy (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

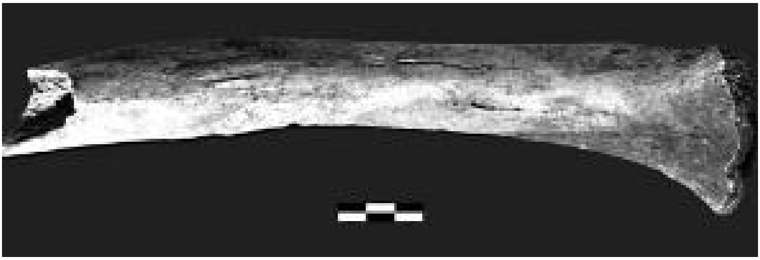

Figure 3.8 Eleutherna: Skeleton 005ie, subperiosteal hematoma on the tibial shaft associated with scurvy (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

tibia.[74] In scorbutic non-adults, periosteal attachment can become so fragile that a subperiosteal hemorrhage often involves a proportionately greater area and volume. The absence of repair activities in the bone tissue along the margins of the infraction in this skeleton may indicate that there was only a short interval between the injury and the moment of death, perhaps a few hours or a few days.

74 Ortner 2003, 384.

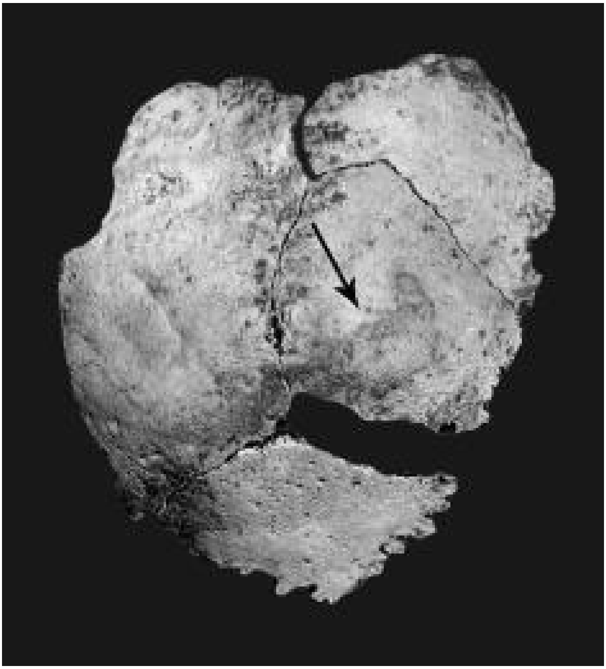

Figure 3.9 Eleutherna: Skeleton 004e, porous lesions on the occipital bone (arrow) associated with scurvy (photo: K. Painesi. Courtesy of Prof. P. Themelis and the Society of Messenian Archaeological Studies)

In any case, the process of fracture repair is known to be greatly impaired in hypovitaminosis C.

It is possible that these non-adults did not develop more extensive hemorrhage-induced subperiosteal bone formation because death, perhaps from an alternative cause, occurred relatively soon after the onset of scurvy. Vitamin C has a dual role in maintaining adequate immune function by assisting in neutralizing or destroying pathogens and by producing various protective antioxidants.[75] Children with vitamin C deficiency are especially susceptible to infections, developing otitis media, pneumonia, diphtheria and other health problems, such as digestive disturbances and general debility.[76]

A variety of pathologies can result in porous lesions of the skull, which are often attributed to anemia when accompanied by thickening of the bone marrow, to infection or to other inflammatory conditions that can stimulate an increase in

75 Jacob and Sotoudech 2002.
76 Jaffe 1972.

vasculature, as well as new bone formation. The changes observed in the orbital roofs are not typical for cribra orbitalia characteristic of anemia because they are not caused by the expansion of underlying marrow, which would be the case in anemia, and they occur in conjunction with an intact cortex.[77] In addition, there is no convincing evidence of bone deformity and/or bone changes in the skull that can be associated with rickets.

Scurvy has been thought to be rare in fruit-abundant areas, but common at high altitudes. It is uncertain whether ancient Greek, Byzantine and Arab physicians recognized scurvy as a clinical condition, since the temperate climate of the Mediterranean and Near East encourages the cultivation of vitamin C-rich fruits and vegetables.[78] Even during famines the inhabitants of Greece never lacked fresh produce and seafood.[79]

The observed scorbutic cases count for only 1.1% of the non-adult sample. If we accept that the rarity of scurvy in the paleopathological record of Greece can be explained by the temperate climate of the country and the abundance of vitamin C-rich fruits and vegetables, how can we interpret its sporadic presence? In a broader context it should be remembered that changes in subsistence patterns probably had a significant impact on the nutritional status of past populations. Sedentism and the transition to agriculture may have had benefits (greater food production) but also disadvantages, such as the adoption of diets containing a far more restricted range of plants. It has been suggested that populations could have moved from a diet of as many as 200–300 species of plant foods to one of a couple of domesticated cereals and probably only 20–50 plant foods.[80] Cereal grains (for example, wheat), which would have formed the basis of a daily diet, lack vitamin C.[81] Scurvy does not usually develop under 'normal' living conditions, but it is commonly associated with natural or man-made disasters. Impoverished living conditions and environmental stress are attested for the scorbutic cases from the late Roman/early Byzantine sites of Stymphalos and Eleutherna.[82] Populations undergoing stressful periods due to economic, political or environmental turbulence are potentially more at risk of developing the condition. The development of the condition is often associated with specific

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77 Ortner and Putschar 1985, 263.

78 The Hippocratic writers of the late fifth century BC may have known of scurvy, as they mention gum lesions and leg pains; see Aufderheide and Rodríguez-Martín 1998, 312.

79 Grmek 1989, 77.

80 Cordain 1999, 23.

81 This link between the development of scurvy and the adoption of agriculture is suggested by Papathanasiou 2005 for the case she reports from the Neolithic (3500–2900 BC) site of Alepotrypa cave in Greece.

82 Bourbou 2004; Garvie-Lok 2008.

culturally derived behaviours. Weaning practices, including the introduction of cereal-based supplementary foodstuff after cessation of breastfeeding, should be taken under consideration, as metabolic conditions are often argued to coincide with weaning.[83] Finally, it is possible that sample biases, lack of systematic work on non-adult populations and misdiagnosed cases may have resulted so that only few cases have entered the paleopathological record.

Non-Specific Infections

Periostitis

Periostitis (or periosteal new bone formation) refers to the deposition of a new layer of bone under an inflamed periosteum as the result of injury or infection.[84] Non-adults are more susceptible to bone infection, due to the abundant blood supply in the red bone marrow at the ends of the long bones. Although a good blood supply is essential to maintain rapid growth in these areas, it is also a route for the transportation of foreign organisms to these sites.[85] Since diagnosis of periostitis in non-adults is rather problematic, few cases have entered the palaeopathological record.[86] Problems in diagnosis basically arise from difficulties in distinguishing between pathological change and normal growth processes, especially in infants and children, or between different pathological conditions.[87] In archaeological bones observation of the lesions' patterning (single bones or specific distribution pattern), as well as the nature of the new bone deposits, facilitates the diagnosis and interpretation of the condition.

Table 3.4 Periostitis in the non-adult sample (individuals affected)

Site	Total no.	Affected	CPR%
Eleutherna	51	2	3.9
Kefali	40	3	7.5
Stylos	16	2	12.5
Total	*107*	*7*	*6.5*

83 Bourbou and Garvie-Lok 2009.

84 Lewis 2007, 134.

85 Ulijaszek 1990.

86 Mensford et al. 1978; Grauer 1993; Anderson and Carter 1994; Ribot and Roberts 1996; Walker 1997.

87 This fact led Ribot and Roberts 1996, 71 to highlight the need of microscopical applications and agreement on the minimum requirement for scoring subperiosteal new bone formation on the long bones and skull in individuals under the age of 6 ± 2 years.

In non-adult individuals of the sample localized periostitis is observed along the shafts of one or two long bones (Tables 3.4 and 3.5). Seven non-adult individuals or 4.0% exhibited periosteal reaction. Absolute frequency rate is 4.6% or ten affected bones of 216. When comparing between time periods, five individuals (3.7%), and two individuals (5.0%) are attested for the early and middle Byzantine period respectively. Absolute frequency rate is 3.8% or seven bones of 183 for the early Byzantine sites, and 9.0% or three bones of 33 for the middle Byzantine sites.

Table 3.5 Periostitis in the non-adult sample (bones affected)

Site	Total bones	Bones affected	TPR%
Clavicle			
Kefali	24	1	4.1
Scapula			
Stylos	7	1	14.2
Humerus			
Kefali	42	2	4.7
Radius			
Kefali	26	2	7.6
Femur			
Eleutherna	61	1	1.6
Stylos	13	1	7.6
Total (femur)	*74*	*2*	*2.7*
Tibia			
Eleutherna	30	1	3.3
Stylos	13	1	7.6
Total (tibia)	*43*	*2*	*4.6*
Total	*216*	*10*	*4.6*

The loosely organized woven bone suggests that the lesions were still active at the time of death (Figure 3.10).[88] It is possible that a general ongoing infectious process affected the individuals since birth or even before, and contributed directly to their early death. Trauma is another possible diagnosis due to the localized nature of the lesion and the normal internal architecture of all of the bones.[89]

[88] New bone layers disorganized and porous in appearance (woven bone) represent an active phase; remodeled and continuous with the original cortex (lamellar bone) indicate that the condition occurred and healed before the individual's death; a mix of both types represents a chronic and active case.

[89] Anderson and Carter 1994.

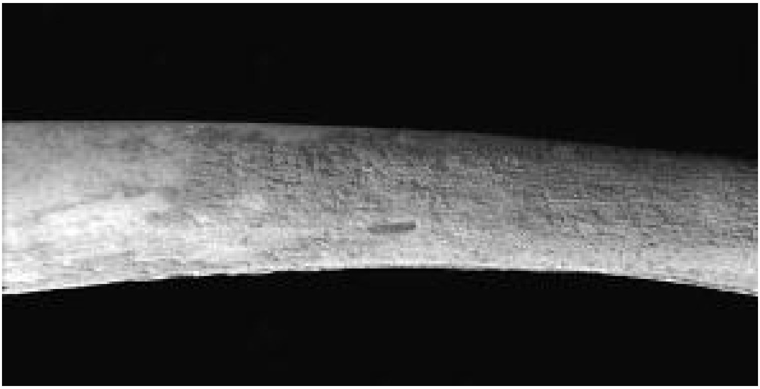

Figure 3.10 Stylos: Skeleton 003, non-specific periostitis on the left tibia

Infantile cortical hyperostosis

The specific etiology of infantile cortical hyperostosis (ICH) or Caffey's disease is still unknown, but it is most possibly related to a viral infection. Other possible etiologies include genetic defects, hypervitaminosis, trauma, arterial abnormality or an allergic reaction of collagen.[90] The condition comprises swelling, irritability and bone lesions characterized by massive deposition of layered periosteal woven bone on one or several bones in a rough and uneven contour.[91] The average age of onset is 9 weeks but cases of recurrent ICH have been reported in individuals up to 19 years of age.[92] The spontaneous healing of the condition, usually within three months, leaves no traces behind, thus hindering possible diagnosis in archaeological bones.[93]

Skeleton 007 from Stylos (7.5–8.5 years of age) exhibits porotic hyperostosis on the right parietal bone and diffuse periosteal reaction in the form of woven bone on almost all recovered bones (Figure 3.11): both mandibular rami, both radii, both ulnae, seven right and 12 left ribs, both ilia, ischia and pubic bones, both femora, both tibiae (Figures 3.12), both fibular shafts (recovered in fragments) and both calcanei. The distribution pattern of the periosteal lesions indicates infantile cortical hyperostosis as the most plausible diagnosis. Current clinical data suggest that the skeletal lesions indicative of ICH include the

90 Caffey 1978; Lewis 2007, 144.

91 Lewis 2007, 143.

92 Keipert and Campbell 1970; Swerdloff, Ozonoff and Gyepes 1970.

93 Only a few cases are reported: see Rogers and Waldron 1988; Farwell and Molleson 1993; Bagousse and Blondiaux 2001; Lewis and Gowland 2005.

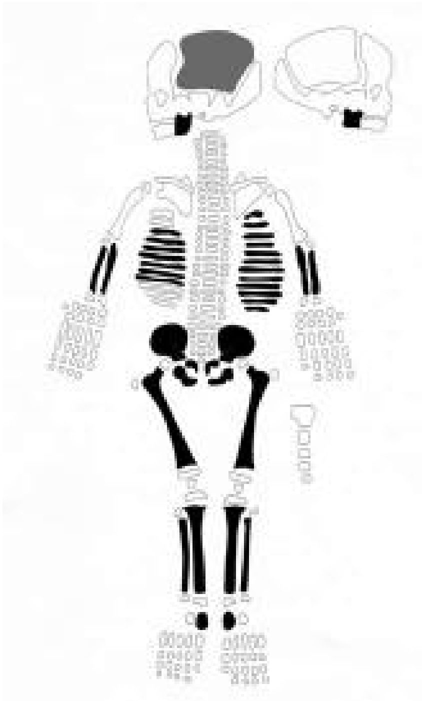

Figure 3.11 Diagram of skeleton 007, from Stylos. In black color are indicated the areas affected with periostitis; in grey color are indicated the areas with porotic hyperostosis

Figure 3.12 Stylos: Skeleton 007, diffuse periosteal reaction on both tibiae (photo: C. Bourbou)

mandible, clavicle and long bones.[94] Although the condition is not fatal in itself, factors such as the general immune status of the individual and nutritional and hygiene conditions may have contributed to the child's death.

Tentative diagnoses include scurvy and hypervitaminosis A. Skeletal evidence for scurvy consists of new bone formation, potentially anywhere on the skeleton; however although woven bone was present on both mandibular rami, other pathognomonic features of the condition are missing due to the fragmentary preservation of the skull, or not present. Diffuse periosteal activity is also present in cases of hypervitaminosis A along with cortical hyperostosis and usually becomes manifested no earlier than the end of the first year of life.[95]

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94 Couper, McPhee and Morris 2001. Lesions may be asymmetric, sparing the metaphyses and epiphyses: see Lewis 2007, 144, fig. 7.5.

95 Resnick 1995, 3345.

Chapter 4
The Byzantine World on a Plate

Evidence from Documentary Sources

Through the process of cooking, raw products are transformed into a signifier of culture where people meet and interact.[1] Recipes surviving from the Byzantine period tell of luxurious feasts offered during imperial dinners, while a daily peasant diet relied on the basic foodstuffs. Both of these settings – an imperial banquet summoning the most prestigious and powerful elite and a traditional meal among members of a peasant family – represent the ideology, rituals and social and moral values of Byzantine society.[2] What did people eat in Byzantine times? The answer to this question has been the main subject of congresses such as the one-day meeting *Food and Cooking in Byzantium* (Museum of Byzantine Culture, Thessaloniki, 2001) and the 37th Spring Symposium of Byzantine Studies, *Eat, Drink and Be Merry (Luke 12:19): Production, Consumption and Celebration of Food and Wine in Byzantium* (University of Birmingham, 2003), and also of special volumes such as *Feast, Fast or Famine: Food and Drink in Byzantium* (Australian Association for Byzantine Studies, 2005). These congresses and publications have focused on topics such as the most frequently consumed foodstuffs, methods of preparation and cooking, and the preservation of various products in Byzantium. But were the Byzantines aware of the nutritional quality and importance of certain foodstuffs and the quantity and frequency of meals needed for a balanced diet, as suggested by Byzantine physicians in their works? Several versions of such a 'dietary calendar' exist, some of them attributed to a certain Hierophilos, which relate that specific categories of products must be consumed according to the season and climate; but it is highly speculative to argue for a widespread and firm application of such a daily regimen.[3]

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1 Lévi-Strauss 1969.

2 For imperial dinners as a way for the emperor to disseminate political propaganda, see, e.g., Malberg 2007.

3 The dietary comments in these versions are taken from a pamphlet attributed to a certain sophist, Hierophilos, of uncertain date; the name is probably intended to hint at the Herophilos, who was a major figure in classical medicine (335–280 BC); see Romano 1999; Dalby 2003, 161–9; Koder 2007, 67–72.

Documentary evidence and artistic representations have traditionally served as the primary sources of information about the Byzantine diet. Literary sources include regulations for the taxation and sale of foods, physicians' comments on diet, travelers' tales, records of supplies purchased for troops or ships' crews and the dietary regimens at monasteries.[4] Artistic representations such as religious images, illustrations in manuscripts and the mosaics and wall paintings of churches, palaces and houses, especially during the fifth and sixth centuries AD, depict the bounty of nature and the food sources available to the Byzantines.[5] However, one must decipher and extract information from them with caution, due to the artistic conventions, stereotypes and symbolism inherent in these depictions.[6]

Briefly outlined here are the main foodstuffs consumed by the Byzantines as attested in the written sources. Oil, wine and wheat formed the basic elements of the Byzantine diet – what Braudel calls the 'essential trinity' of Mediterranean crops.[7] The grains in primary use appear to have been wheat and barley, especially wheat.[8] Another medieval grain crop was millet, whose importance seems to have varied by region and economic status.[9] Other grains traditionally grown or used include oats, rye and rice.[10] Various legumes, such as broad beans, chickpeas, peas, lentils, vetch and lupins, were also consumed.[11]

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4 See, e.g., Koukoules 1952, 9–135; Dembinska 1985; Kaplan 1992; Mango and Dagron 1995; Kislinger 1996; Braudel 1998; Bober 1999; Flandrin and Montanari 1996; Talbot 2007.

5 Although mosaics and wall paintings provide images of earthly fruits, agricultural activities, animal husbandry, game, fish and wild fowl, they offer more information on tableware and comestibles than on Byzantine gastronomy and diet; see, e.g., Mundell Mango 2007; Vroom 2007.

6 For a thorough discussion of the use of artistic sources for studying Byzantine food, see Anagnostakis and Papamastorakis 2005, 147–72; Maguire 1987, 2005.

7 Braudel 1966, 215. For the prices of cereals and other important foodstuffs such as oil, wine, meat, cheese and fish, which not only are of interest to the researcher from a statistical point of view but have much to say on Byzantine standards of living, agricultural production and the laws of the market, see Cheynet 2005. On oil and wine, see also Koukoules 1952, 121–9; Anagnostakis 1995, 1996; Koder 2005, 26; Tsougarakis 2007; Stathakopoulos 2007b; Anagnostakis 2008.

8 See Braudel 1966; Teall 1959; Dalby 1996, 2003; Kazhdan 1997; Motsias 1998.

9 In Roman times millet had been considered a food of the poor; see Garnsey 1988; Gallant 1991. The same notion of millet as an inferior food is shared by the Byzantine physician Symeon Seth; see Teall 1959, 99. Matthaiou 1997 also argues that millet was taxed at a lower rate than other grains in Ottoman Greece.

10 Oats and rye were of minor significance, but rice became quite important in later times; Dalby 1996.

11 Vetches were commonly used as animal feed or sown to enrich soil, while lupins were eaten by both humans and animals, becoming more important as a human food when

Historical documents indicate that sheep, goats, pigs, chickens and cattle were the main domesticated animals in the Byzantine countryside, with sheep and goats predominating.[12] In addition to domesticated animals and birds, hunted and collected meat was likely included in the diet.[13] Since meat turns bad quickly, it was often processed.[14] Freezing and freeze-drying as well as smoking of food were not common in Byzantine times.[15] The use of snow and ice for preserving meat is mentioned in the *Geoponica*, but this seems to be an exception and not a practice in daily use.[16] The most effective way of preserving meat must have been a combination of drying and salting.[17] The milk of sheep and goats was predominantly used for the production of dairy products such as cheese,[18] yogurt and butter.[19] Less frequently mentioned is another dairy preparation, *trachanas*, a dried mixture of milk, cheese and roasted grain.[20]

Most of the marine species known to have been consumed in the Roman era are also mentioned in Byzantine times.[21] More than 110 names of fishes and about 30 names of other aquatic organisms are found in the Byzantine literature.

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other crops failed; Dalby 1996; Motsias 1998.

12 Faunal remains retrieved for stable isotope analysis from the sites of Eleutherna, Sourtara and Kastella include sheep, goat, pig, dog and red deer (see below). Published analyses of animal bones from Byzantine contexts are rare; see, e.g., Nobis 1993; Mylona 2008a, in her study of the animal remains from the middle Byzantine house at Pyrgi (Hagia Anna), has identified nine different species, including donkey, cow, pig, sheep, goat, wild goat, red deer, chicken and possible hare or rabbit. Sheep outnumber goats, while pigs and cows are the next most commonly encountered animals. Mylona 1997, 2003, 2008b has also studied animal remains from the late Roman/early Byzantine (fifth to seventh centuries AD) house complex at Itanos in east Crete. Besides the great number of fish bones (see below), the sample also included mammal and bird remains.

13 Dembinska 1985; Kazhdan 1997; Dalby 2003; Motsias 1998. Koder 2005, 22 argues that no veal was consumed and that chicken was not frequently consumed.

14 Frost 1999; Anagnostakis 2005, 88–90; Grünbart 2007, 45–8.

15 Hellmann 1990; Koder 2007, 60.

16 *Geoponica* (ed. Beckh 1895), XIX.9.2; Weber 1980, 83.

17 For a brief overview of the process, see Grünbart 2007, 48.

18 Braudel 1966; Kazhdan 1997; Dalby 2003, 72–4.

19 Motsias 1998.

20 This was a travel food, prepared for consumption simply by stirring it into hot water. It was important to soldiers and shepherds; Hill and Bryer 1995.

21 A variety of fishes are portrayed as the protagonists of the satire *Psarologos* (ed. Krumbacher 1903). See also Koukoules 1952, 79–88 (on the various species) and 331–41 (on the fishing modes and devices applied); Dagron 1995; Braund 1995; Dalby 1996; Maniatis 2000; Kislinger 2005, 52. Reports on fish remains from Byzantine sites are rare. The very rich assemblage recovered at Itanos included small and large fishes of coastal varieties, belonging to members of four families: sea breams (Sparidae), parrot-fish (Scaridae), groupers/combers

Most of the information has been retrieved from medical texts, whose writers are dealing with food and nutrition. In these texts fishes are classified into categories based on their physiology (*sklirosarkoi*, *skilorosarkoi plateis*, *malakosarkoi* or *apalosarkoi* and *mesaioi*) and origin (*aigialodeis* or *aigialeioi*, *petraioi*, *pelagioi*, *thalassioi*, *potamioi* and *limnaioi*), since these are determining factors for the nutritional value of each species.[22] Preserved fish (salted or dried) and preserved fish eggs such as caviar (sturgeon eggs) and botargo (salted and pressed mullet roe) were likely to have been important; additionally, there is evidence for the use of fish sauce (*garum*).[23] However, Koder argues that *garum* was not common or popular between the early Byzantine period and the eleventh century, or even later, since the word *garon* is rarely found outside lexica and medical texts.[24]

Finally, fruits (grapes, figs, melon), vegetables (celery, lettuce, endive, cress, kohlrabi, turnips, eggplant, cabbage) and wild vegetables gathered in season were also included in the Byzantine menu.[25] Nuts (almonds, chestnuts, pistachios, walnuts, pine nuts) appear to have also formed a significant portion of the diet.[26] Known and well appreciated was honey, which also served as a basic component of various desserts.[27]

Archaeological findings and medical and hagiographical texts provide useful information on practices of feeding the newborn. The topic of the cruel separation of young mothers and their breastfeeding infants by death is often found in funerary inscriptions from the Byzantine period. An example of these is the inscription (sixth century AD ?) associated with a funerary monument found in the area of the Panathenaic Stadium, commemorating a young mother whose death left her children 'in need of milk'.[28] Magico-religious actions associated

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(Serranidae) and picarels (Centracanthidae). Turtle and seashell remains were also included. For these remains, see Mylona 1997, 2003, 2008b; for the excavation, see Greco et al. 1998.

22 See, e.g., Chrone-Vakalopoulos and Vakalopoulos 2008; the authors provide a systematic terminology of the fishes and the various aquatic organisms attested in the Byzantine sources, and identify each species with its current scientific name.

23 Dalby 1996. For the preparation of *garum* see Koder 2005, 24–5.

24 Koder 2007, 72.

25 To make fruits available the whole year, drying was the simplest and commonest process; see Grünbart 2007, 43–4. Vegetables were consumed fresh, dried or preserved in salt and vinegar, like modern pickles; see Koukoules 1952, 88–102; Teall 1959, 98–100; Koder 1992, 1995, 2005, 23–4; Littlewood, Maguire and Wolschke-Bulmahn 2002; Dalby 2003, 74–7; Anagnostakis and Papamastorakis 2005, 158–66. A wealth of information on fruits and vegetables can be found in the Byzantine poem *Porikologos* (ed. Winterwerb 1992).

26 Motsias 1998.

27 Anagnostakis 2000; Koder 2005, 26.

28 Sironen 1997, 236, no. 195, translates the text of the inscription as follows: 'The good Athenodora of Attica, the religious wife of Thaumasius, who gave birth to little children

with mothers failing to produce milk for their newborns, such as the use of specific herbs or amulets made of *galatopetra*, are also attested.[29] Although the archaeological record has not yet revealed any examples of feeding-vessels from the Byzantine period, we can securely assume that they existed, as written sources attest attempts at artificial feeding.[30] The hagiographical text describing the Vita of St Theodore Tiron (the Recruit) relates that after the death of Theodore's mother, his father succeeded in manufacturing a breast-shaped glass vessel for feeding the infant until solid food could be introduced.[31]

Byzantine physicians included in their works chapters on the care of the newborn and especially on perinatal nutrition, conveying the eclectic knowledge of physicians of the Roman imperial period, such as Rufus and Soranus from Ephesus (first century AD), enriched with additional remarks and clarifications based on their own experience.[32] Oribasius gave detailed information concerning a child's nutrition from birth through the age of 14, focusing mainly on the first two years,[33] and Aetius of Amida and Paul of Aegina followed Oribasius' recommendations on perinatal nutrition and weaning patterns.

Although physicians advised a considerable wait between birth and the onset of nursing, breastmilk was seen as the infant's ideal food. During in-utero life the growing fetus receives all essential nutrients via placenta transfer from the mother. After birth breastmilk provides the newborn with immunological protection and a supply of nutrients, as it contains over 100 different constituents that contribute to the health, growth and development of the newborn.[34] Physicians in the past failed to recognize the nutritional and immunological importance of colostrum, which is present in the first few days after birth and is replaced by mature milk by the tenth day of breastfeeding. Due to its different color (lemony-yellow) and consistency, it was often denied to the newborn. Oribasius was specific in urging that the child ought not to be fed colostrum, which he felt

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and nursed the infants, the soil has taken away the young mother and holds her while the little children are in need of milk.'

29 Papamichael-Koutroumpa 1977–78.

30 In Western Europe some rare examples of medieval feeding-vessels have been found; see, e.g., Coulon 1994; Crawford 1999.

31 *Vita of Theodore Tiron* (Sigalas 1925), 225. For a discussion of this testimony, see Kiousopoulou 1997, 67; Rey 2004, 373.

32 An approach to the study of perinatal nutrition and weaning patterns as attested in the sources and their relevance to the isotopic signature of chemical analysis is included in the paper by Bourbou and Garvie-Lok 2009; see also Rey 2004.

33 Beaucamp 1982.

34 For example, carbohydrates in the form of lactose prevent the development of rickets, while iron and zinc are essential for growth. See the thorough discussion in Lewis 2007, 97–9.

to be harmful. He argued that immediately after birth the newborn must be fed with clear honey of high quality, followed by drops of a lukewarm solution of honey and water (*hydromel*) to be given slowly over the subsequent four days, and he advised against feeding a newborn other foods, including butter, which he thought was too heavy for the stomach of the newborn.[35] After this period nursing could commence, with the infant receiving two or three meals per day. Aetius of Amida and Paul of Aegina, following Oribasius, suggested as well that the first food given to a newborn should be honey, and afterward milk.[36] The attention that medical writers devote to the proper selection of a wet nurse suggests that often a child would not be nursed by its own mother.[37] Beaucamp's research confirms the high degree to which the medical texts reflect ordinary behavior. Her results, based on the investigation of late Antique Egyptian documents, suggest that although hiring a wet nurse was considered the ideal, this was not usually possible for the poor.[38]

Medical writers, in general, saw weaning as a fairly serious step to be approached with caution, and suggested a gradual weaning process.[39] Soranus indicated that before the age of 6 months, when a baby's body becomes firm

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35 *Oribasius* (Raeder 1928–33), V, 5. Soranus suggested that a newborn must stay away from any kind of food for at least two days, until its body was fully recovered from the process of birth. After this interval, the baby should be given food to lick, such as *hydromel* or honey mixed with goat's milk. Soranus rejected other popular choices of butter, southernwood with butter, nosesmart or kneaded barley meal for this first food, claiming that they were too hard on the child's sensitive gastrointestinal system, *Soranos d'Ephèse* (ed. and tr. Burguière, Gourevitch and Malinas 1990), II, 11; Temkin 1991, 88. Medieval writers in Western Europe as well denied colostrum to the newborn; instead a newborn was fed with butter, the oil of sweet almonds, sugar, honey and the syrup of wines; Fildes 1986, 1995; Orme 2001 58–60, 66.

36 *Aetius of Amida* (Olivieri 1935), IV, 3; *Paul of Aegina* (Heiberg 1921 and 1924), I, 5.

37 *Oribasius* (Raeder 1928–33), V, 2–3; *Aetius of Amida* (Olivieri 1935), IV, 4–6; *Paul of Aegina* (Heiberg 1921 and 1924), I, 2–3. Soranus suggested that breastmilk should come from a wet-nurse for the first 20 days, as mother's milk was in most cases unwholesome during this period; *Soranos d'Ephèse* (ed. and tr. Burguière, Gourevitch and Malinas 1990), II, 12–14; Temkin 1991, 90–101. Although Soranus argued that after the initial 20 days a baby should ideally be nursed by its mother, he also commented that a wet-nurse was preferable in many cases to prevent exhaustion of the mother; *Soranos d'Ephèse* (ed. and tr. Burguière, Gourevitch and Malinas 1990), II, 11; Temkin 1991, 90.

38 Beaucamp 1982.

39 Medieval writers in western Europe also recommended the gradual cessation of breastfeeding by about 2 years of age; Shahar 1990. Liquid or semi-liquid foods such as animal milk, gruel or pap (a mixture of flour and bread cooked in water) might be given prior to the emergence of the first teeth, before about 6 to 9 months of age; afterwards other foods might be introduced; Fildes 1986, 1995, 101–26.

enough to tolerate solid food, an infant should be fed only milk.[40] At 6 months the first solid food could be given: crumbs of bread softened with *hydromel*, milk, sweet wine or honey with wine. Later an infant could also be given soup made of spelt, very moist porridge or an egg cooked soft enough to be sipped.[41] The introduction of solid foods at around 6 months of age did not herald an abrupt weaning process. Instead, Soranus advised a diet of breastmilk supplemented by the soft solid foods described above for at least another year. When development of the teeth allowed an infant to chew more solid foods, at around 18 to 24 months, Soranus recommended that gradual weaning of the infant should begin.[42] Oribasius was in agreement with this general time frame, treating the time before the age of 2 as the period during which the child would be nourished by milk.[43] The same notion is shared by Aetius of Amida, recommending weaning at around 20 months, and by Paul of Aegina, suggesting that a child may be brought up on milk until the age of 2 years; afterwards its diet may be changed to cereal food.[44]

Useful information about the age of weaning can also be found in the *Vitae* and miracles of saints. In the Miracles of St Thekla a child who has just been weaned is said to be old enough to walk and run, suggesting that it was at least 18 months old.[45] In the Vita of Symeon Stylites the Younger, Symeon, after his baptism at age 2, refused to nurse from his mother as she had eaten meat that had been sacrificed to idols, indicating that children could still be breastfeeding at age 2; the hagiographer also relates that when Symeon began to eat solid food his mother gave him honey on bread to eat and water to drink.[46] The Vita of St Alypios relates that the saint was taken to church by his mother at the age of 3 after his father had died, and that at this point he had already been weaned.[47] In the Vita of Michael Synkellos we see a reference to a boy who had been weaned and had reached the age of 3 years.[48] Finally, the Vita of Basil the Younger

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40 Soranus rejected the early introduction of cereal food, commonly given as soon as 40 days after birth; *Soranos d'Ephèse* (ed. and tr. Burguière, Gourevitch and Malinas 1990), II, 21; Temkin 1991, 117.

41 *Soranos d'Ephèse* (ed. and tr. Burguière, Gourevitch and Malinas 1990), II, 21; Temkin 1991, 117.

42 *Soranos d'Ephèse* (ed. and tr. Burguière, Gourevitch and Malinas 1990), II, 21; Temkin 1991, 118–19.

43 *Oribasius* (Raeder 1928–33), V, 5.

44 *Aetius of Amida* (Olivieri 1935), book IV, 28; *Paul of Aegina* (Heiberg 1921 and 1924), book I, 5.

45 *Vita of Saint Thekla* (ed. Dagron 1978), mir. 24, p. 350.

46 *Vita of Symeon Stylites the Younger* (ed. van de Ven 1962), ch. 5–6, p. 7.

47 *Vita of Saint Alypios* (ed. Delehaye 1923), 149.

48 *Vita of Michael Synkellos* (ed. Cunningham 1991), 46.

includes a description of a woman holding in her arms a sickly child aged 4 years who was breastfeeding.[49]

Thus, the written sources suggest a weaning process that was generally quite gradual. Although physicians advised that breastmilk be withheld for a period immediately after birth, they recommended that the child should be nursed for some time. While the introduction of solid food by roughly 6 months of age was suggested, the child was not to be weaned abruptly at this time; rather, adult foods were to be introduced gradually and the child would not have been completely weaned until the age of 2, if not later. The *Vitae* and miracles of the saints suggest that this advice was heeded (or, perhaps, that it reflected common practice), as they suggest that there was a prolonged period of weaning and that nursing persisted until a child was at least 2 years of age and, in some cases, as old as 4 years.

Are We What We Eat?

Documentary evidence has been traditionally used to reconstruct past diets and weaning patterns. The study of specific pathological conditions, such as dental diseases or metabolic disorders, has also been used to indicate the type and quality of diet. In recent decades the application of stable isotope analysis of human remains has provided an alternative source that has greatly contributed to the investigation of dietary patterns in past populations. Together documentary and isotopic evidence have the potential to provide a detailed portrait of diet and weaning in the past. The following sections will present basic background information on stable isotope analysis and a number of issues that must be taken under consideration in order to securely interpret the chemical signature on human remains when projected against documentary evidence.

Stable Isotope Analysis: Some Essentials

Isotopes are chemical elements with the same number of protons in their nuclei, but different numbers of neutrons.[50] They are basically the same in terms of their chemical properties, but differ slightly in weight. Carbon has two stable isotopes (^{12}C and ^{13}C), as does nitrogen (^{14}N and ^{15}N); for both elements the lighter stable isotope (^{12}C, ^{14}N) is abundant, while the heavier (^{13}C, ^{15}N) is much rarer. The relative content of the two carbon or nitrogen isotopes in a material

49 *Vita of Basil the Younger* (ed.Viliskij 1911), 316.37.

50 For more detailed information on the measurement and behavior of stable isotopes, see Hoefs 2004.

is expressed by its stable carbon isotope ratio ($\delta^{13}C$ value) or stable nitrogen isotope ratio ($\delta^{15}N$ value). These express the ratio of one isotope to another in terms of its departure in per mil (‰) from the value of an international standard, with a negative value indicating depletion in the heavier isotope relative to the standard, and a positive value indicating enrichment.[51] Typically, the $\delta^{13}C$ values of living organisms are negative and their $\delta^{15}N$ values are positive.

The stable isotopes of an element are essentially identical chemically, participating in the same reactions to produce the same molecules. However, the slight difference in their weights can cause one isotope to participate in a reaction more readily than the other, causing the stable isotope value of the products of the reaction to differ from that of the reactants. This and other mass-dependent processes cause variation in the stable isotope ratios of different substances. For living organisms this variation follows a predictable pattern, allowing aspects of diet and behavior to be inferred from the stable isotope ratios reflected in bone collagen, the structural protein of the bone tissue.[52] The main aim of most isotopic analyses is to use the carbon isotope ratio ($\delta^{13}C$) to determine the amounts of marine vs. terrestrial foods, or C_3 vs. C_4 plant foods (or animal products), as well as to obtain further information on the protein sources from the nitrogen isotope value ($\delta^{15}N$), such as the amount of animal vs. plant protein.[53]

Following the first documentation of the effects of nursing and weaning on human $\delta^{15}N$ values, stable nitrogen isotope analysis has been used to study nursing and weaning in a number of archaeological human populations.[54] This

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51 The primary standard for carbon is a marine carbonate fossil from the PeeDee formation in South Carolina and is referred to as PDB (for PeeDee belemnite), and the standard for nitrogen is atmospheric nitrogen, which is referred to as AIR; Katzenberg 2000, 313, table 11.2.

52 Katzenberg 2000; Mays 2000; Sealy 2001.

53 See, e.g., Bocherens et al. 1991; White, Healy and Schwarcz 1993; Ubelaker, Katzenberg and Doyon 1995; Mays 1997; Richards et al. 1998; Herrscher et al. 2001; Herrscher 2003; Polet and Katzenberg 2003; Müldner and Richards 2005; Jay and Richards 2006; Richards, Fuller and Molleson 2006; Müldner and Richards 2007a, 2007b; Salamon et al. 2008; Rutgers et al. 2009; Keenleyside, Schwarcz and Panayotova 2006; Keenleyside et al. 2009; Craig et al. 2009.

54 See, e.g., Katzenberg, Saunders and Fitzgerald 1993; Katzenberg and Pfeiffer 1995; Katzenberg, Herring and Saunders 1996; Schurr 1997; Herring, Saunders and Katzenberg 1998; Wright and Schwarcz 1999; Dupras, Schwarcz and Fairgrieve 2001; Richards, Mays and Fuller 2002; Fuller, Richards and Mays 2003; Prowse et al. 2004; Schurr and Powell 2005; Williams, White and Longstaffe 2005; Fuller et al. 2006a; Fuller et al. 2006b; Richards, Fuller and Molleson 2006; Clayton, Sealy and Pfeiffer 2006; Dupras and Tocheri 2007; Jay et al. 2008.

application is possible because changes in the $\delta^{15}N$ value of an infant's diet are also reflected in its bone collagen. The most common approach to studying weaning through archaeological remains is the study of bone samples from a number of infants and children in a burial group. These samples are analyzed and their $\delta^{15}N$ values are plotted by age at death and compared to the mean value for adult females in the population. Typically, such studies show $\delta^{15}N$ values for neonates that are similar to those of adult females. The values then rise fairly rapidly to roughly one trophic level above the mean adult female value as nursing incorporates ^{15}N-enriched collagen into the bones. After a given age, they begin to drop again; the point at which this drop begins is taken to be the age by which weaning typically began for the population in question. Observations made on fingernail clippings of modern human mothers and their babies show how this effect leads to shifting $\delta^{15}N$ values in the tissues of infants as they are born, nurse and are weaned.[55]

Generally speaking, bone as a tissue is slow to turn over, and the bones of adults may retain the isotopic signal of an earlier diet for many years. However, bone turnover in a rapidly growing infant is considerably faster, especially in small and porous bones such as the ribs. Observations on large samples of infants from archaeological skeletal populations have led researchers such as Katzenberg, Herring and Saunders, and Richards, Mays and Fuller to suggest that the lag time between weaning and a shift in infant rib $\delta^{15}N$ value is quite brief, on the order of a few months or less.[56] Although powerful, this application of stable nitrogen isotope analysis has its limitations and requires caution; for example, the onset of a drop in $\delta^{15}N$ values must be taken as the time by which weaning had typically begun for a population, rather than a precise estimate of weaning age, and problems arise from differences between the approach taken in weaning healthy and sick infants, as the weaning pattern reflected in the deceased infants from a burial population is more likely to reflect the approach preferred for an unhealthy child.[57] Because of these issues, and because of a certain normal variation in weaning age expected for any population, it is preferable to examine a large number of infants from several sites before weaning practices in a given era can be confidently reconstructed.

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55 Fogel, Tuross and Owsley 1989.

56 Katzenberg, Herring and Saunders 1996; Richards, Mays and Fuller 2002.

57 For some discussions of these, see Katzenberg, Herring and Saunders 1996; Fuller et al. 2006a, 2006b.

The Relative Importance of Foodstuffs in the Byzantine Diet

In many cases the written sources do not identify the actual consumption of specific products in the Byzantine diet. Surveying various Byzantine texts, Koder notes that certain vegetables were a non-recommended and low-esteemed food.[58] Although elaborate recipes survive for legumes, such as chickpeas and lentils flavored with imported spices, the reliance on legumes is less clear than for grain.[59] The available data suggest that the real consumption levels of legumes were sometimes quite low.[60] Similarly, assessing the frequency of consumption of various marine species and meat, which would have varied regionally and seasonally, is problematic.[61] Some animals were sold in the markets during specific seasons, such as lamb for Easter. In general, some written sources suggest fairly regular meat consumption, while others refer to it only in association with special occasions.[62]

Differential Access to the Products

Social discrimination is marked in a number of products, targeting even basic elements of the diet, such as bread. Various types of bread existed, differing in quality. Bread of lower quality, for example, *mesos* or *mesokatharos artos*, was the bread of the poor, as was *ryparos artos*, bread made of bran or barley.[63] In a lower-status diet, one based on grain and legumes, oil would have provided the main source of fat and a considerable source of calories.[64] Dairy products had special importance in rural diets. However, cheese is also included in urban diets. While some cheeses, such as Vlach, were luxury foods, others appear to have been cheap enough to appear in lower-status diets.[65] Meat of good quality was expensive. It is reasonable to assume that the upper classes must have consumed proportionally

58 Koder 2007, 67–71.

59 For a thorough discussion of spices used during Byzantine times, see Dalby 2002; 2007.

60 Koder 1992.

61 Dagron 1995; Braund 1995; Maniatis 2000; Dalby 2003, 66–9.

62 Dalby 1996, 196; Kazhdan 1997, 55. For example, Koder 2005, 22, argues that meat consumption was in general restricted, and that during the summer and in hot climates it was considered dangerous to consume for it decomposed quickly. See also the publication on vegetarianism and the consumption of meat in late Antiquity and Byzantium by Parry 2005.

63 Koder 2007, 65–6.

64 Braudel 1966; Dalby 1996; Koder 2005.

65 Koder 2005, 20.

higher amounts of it, but the consumption by the average Byzantine person is in more doubt.[66]

Feasting or Fasting? Dining Habits and Fasting Rules of the Byzantine Diet

Dining and fasting habits further complicate any attempt to reconstruct the diet during the Byzantine period. What type of food really belonged to the everyday diet of the Byzantines? Direct written evidence regarding everyday meals and drinks in Byzantium barely exists, in part because people almost never wrote down commonplace or self-evident details of everyday life. Koder provides a basic description of the dining habits and everyday diet of the general population.[67] Normally there were two daily meals: *ariston* or *geuma* was the first meal of the day, sometime late in the morning or at noon; the second meal, *deipnon*, was consumed early in the evening and usually before sunset. A hot cooked meal was usually served only once a day, as *deipnon*, for reasons that range from the great amount of time required to reheat the fireplace to the high cost and shortage of fuel.[68] The basis of the everyday diet for the majority of the population was bread and soup, presumably both of low quality. Such soup included *hagiozoumin*, basically consisting of water, onions, salt, marjoram and a little oil. *Atheras* was another cheap soup, made of semolina or bulgur boiled in water or milk, with drops of oil or other cooking fat.[69] Meat and fish were highly appreciated by the Byzantines, but the high prices of good-quality products, as well as fasting restrictions, prohibited regular consumption of them in large quantities.[70]

Although we should not overestimate the adherence to fasting by the people as a whole, fasting played a significant role in daily diet, since the Byzantines had to refrain from eating specific foodstuffs, especially meat, for a considerable portion of the year.[71] The early Christians took the idea of fasting as a religious practice from Jewish tradition, and by the fourth century it had become a highly praised form of behavior, signifying the struggle for holiness and perfection. For ordinary Christians the figure of the self-mortifying ascetic was an ideal to

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66 Koder 2005, 22; 2007, 59–61.

67 Koder 2005, 17–19; 2007, 62.

68 Materials used for fuel included various types of wood, charcoal, dried dung and scrubland; see Koder 2007, 63; Dunn 1992, 240–49.

69 Koder 2007, 70.

70 Koder 2005, 22–3; 2007, 70–71.

71 Koder 2005, 19 and 2007, 61, notes that the Byzantines had to fast for at least 144 days a year in addition to the usual fasting days of Wednesdays and Fridays. For a thorough overview of fasting rules, see Nicholas and Louvaris 2005; for meat as a target product in fasting rules, see Parry 2005, 178–86.

admire, especially for monks and, most of all, virgins. Jerome (AD 345-420), advising young women on the rules according to which virgins of the Church ought to live, urges extreme frugality in relation to food (recommending vegetables, wheaten bread and occasionally a little fish) and the avoidance of wine.[72] Given this close association of fasting and sexual abstinence in early Christian tradition, it is quite possible that there was a difference in the early Christian era between the kinds and quantities of food eaten by men and by women. Because rules of fasting specifically targeted some key animal products in the diet, they should be considered when reconstructing Byzantine diets.[73]

The Likely $\delta^{13}C$ and $\delta^{15}N$ Values of Some of the Foodstuffs in the Byzantine Diet

Most food plants consumed by the Byzantines, including wheat, barley, legumes, olives and grapes, are C_3 plants, which tend to have tissue $\delta^{13}C$ values in the -33‰ to -22‰ range, with a mean value around -26.5‰.[74] Millet, which is mentioned in the sources,[75] is among the C_4 plants, which tend to have tissue $\delta^{13}C$ values in the -20‰ to -9‰ range, with a mean value around -13‰.[76] The $\delta^{13}C$ values of meat and milk from Byzantine domesticated animals would reflect their diet, with meat somewhat enriched relative to the diet[77] and milk showing a value close to that of the diet.[78] Analyses of domesticated fauna from sites in Greece of Byzantine or slightly later date yielded average collagen $\delta^{13}C$ values of -21.5‰ to -19.6‰ for sheep and goats, -20.3‰ to -19.6‰ for pigs

72 Grimm 1995, 233–6.

73 See also Kislinger 1996, 199–201. Monks formed a special segment of the population, for their fasting included more days throughout the year; see Dembinska 1985; Talbot 2007.

74 Bender 1971; Smith and Epstein 1971; Deines 1980. Olive oil, which may have contributed substantially to the Byzantine diet, has low $\delta^{13}C$ values characteristic of lipids, falling in the -30‰ to -27‰ range; see Spangenberg, Macko and Hunziker 1998; Royer et al. 1999.

75 Teall 1959, 99.

76 Bender 1968, 1971; Smith and Epstein 1971; Deines 1980.

77 See, e.g., Vogel 1978; Tieszen et al. 1983; Tieszen and Boutton 1989; Hare et al. 1991.

78 Data for dairy cattle show whole milk $\delta^{13}C$ to fall within about 3‰ of the animal's fodder; see Minson, Ludlow and Troughton 1975; Tyrrell et al. 1984; Boutton et al. 1988; Metges, Kempe and Schmidt 1990. The $\delta^{13}C$ value of casein, the primary protein of milk, is typically a little higher than that of whole milk; see Nakamura et al. 1982; Kornexl et al. 1997.

and -21.4‰ to -20.2‰ for cows, indicating generally C_3-based fodder.[79] The other major source of potential $\delta^{13}C$ patterning in the Byzantine diet would have been the distinctive values of marine resources. Analysis of a number of modern Aegean food-fish species yielded an average $\delta^{13}C$ value of -17.0‰ for small, low-trophic-level fish (sardine and anchovy) and one of -15.2‰ for larger species of higher trophic level.[80]

When it comes to likely $\delta^{15}N$ values, legumes – a potentially important item in the Byzantine diet – would have had low $\delta^{15}N$ values close to 0‰.[81] The $\delta^{15}N$ values of other plants in the Byzantine diet would fall close to the $\delta^{15}N$ values of the nitrogenous compounds in the soils they grew in, which would vary according to local conditions.[82] Analyses of domesticated fauna from some Byzantine-era sites in Greece found collagen $\delta^{15}N$ values for sheep and goats ranging from 4.0‰ to 6.1‰, for cattle ranging from 3.5‰ to 6.0‰ and for pigs ranging from 3.6‰ to 6.1‰.[83] Values for the animals' meat and milk protein would have been similar.[84] Subtracting a 4‰ trophic level enrichment from these collagen values suggests low $\delta^{15}N$ values in the 0‰ to 2‰ range for plants in the animals' diets; however, extension of these estimates to the $\delta^{15}N$ value of the plants eaten by humans is problematic.[85] Analysis of a number of modern Aegean food-fish species yielded an average $\delta^{15}N$ value of 6.5‰ for small, low-

79 Garvie-Lok 2001; Bourbou and Richards 2007. Samples for some sites extend into the early modern period; however, no significant temporal variation in faunal stable isotope values was seen at those sites; see Garvie-Lok 2001. While average $\delta^{13}C$ values indicate feeding on C_3 resources, a few individual animals have values suggesting a minor C_4 component in their diet; see Bourbou and Richards 2007.

80 Garvie-Lok 2001. Although the impact of recent industrial pollution may have altered Aegean food web $\delta^{13}C$ values, it can still be assumed that marine resources would have contributed an enriched $\delta^{13}C$ signal to Byzantine diets.

81 This assumes that they were cultivated as part of a rotation, in part to restore the available nitrogen of the soil; if grown in soils with abundant available nitrogen, legume values can be similar to those of non-legumes; see Kohl, Shearer and Harper 1980.

82 Delwiche et al. 1979; Kohl and Shearer 1980; Virginia and Delwiche 1982; Shearer et al. 1983; Schoeninger and DeNiro 1984.

83 Garvie-Lok 2001; Bourbou and Richards 2007.

84 Steele and Daniel 1978; DeNiro and Epstein 1978; Hare et al. 1991; Kornexl et al. 1997.

85 There are a number of potential problems with this method, including the possibility that domesticates were fed stems and other waste from legume crops, which would lower their tissue $\delta^{15}N$ values, and the possibility, suggested by Bogaard et al. 2007, that the $\delta^{15}N$ of grain eaten by humans was elevated due to manuring of fields (see below).

trophic-level fish (sardine and anchovy) and one of 10.5‰ for larger species of higher trophic level (Table 4.1).[86]

Table 4.1 Likely $\delta^{13}C$ and $\delta^{15}N$ values for some items of the Byzantine diet

Dietary item	Likely $\delta^{13}C$ values	Likely $\delta^{15}N$ values
C_3 plants	-33‰ to -22‰ range	
C_4 plants	-20‰ to -9‰ range	
Olive oil	-30‰ to -27‰ range	
Sheep and goat	-21.5‰ to -19.6‰	4.0‰ to 6.1‰
Pig	-20.3‰ to -19.6‰	3.6‰ to 6.1‰
Cow	-21.4‰ to -20.2‰	3.5‰ to 6.0‰
Small, low-trophic level fishes (sardine, anchovy)	-17.0‰	6.5‰
Large species	-15.2‰	10.5‰

Isotopic Analysis in Greece

Previous Isotopic Work

In recent years, stable isotope analysis has been widely applied on Greek skeletal populations. The majority of such analyses have included prehistoric material from the Neolithic and Bronze Age periods.[87] A smaller number of studies have included material from the Classical, Hellenistic and Roman periods.[88] Stable isotope analysis in Greek populations was the topic of a special session organized by A. Papathanasiou and M.P. Richards in 2006 during the 16th

86 Garvie-Lok 2001. As with $\delta^{13}C$ values, the impact of recent industrial pollution (especially fertilizer-laden runoff from agricultural areas) may have altered Aegean foodweb $\delta^{15}N$. However, it is still a safe assumption that marine resources would have contributed an enriched $\delta^{15}N$ signal to Byzantine diets.

87 Richards and Hedges 1999; Papathanasiou, Larsen and Norr 2000; Papathanasiou 2001; Triantaphyllou 2001; Papathanasiou 2003; Iezzi 2005; Vika 2007; Lagia, Petroutsa and Manolis 2007; Petroutsa, Richards and Manolis 2007; Richards and Hedges 2008; Richards and Vika 2008; Triantaphyllou et al. 2008; Papathanasiou, Richards and Zachou 2009; Petroutsa et al. 2009; Petroutsa and Manolis 2010; Triantaphyllou et al. 2008, Richards and Zachou 2009; Papathanasiou forthcoming; Iezzi forthcoming; Triantaphyllou and Richards forthcoming.

88 Vika 2007; Vika, Aravantinos and Richards 2009; Vika et al. forthcoming; Lagia and Richards forthcoming.

European Meeting of the Paleopathological Association in Santorini (Greece).[89] Isotopic data show that at the majority of prehistoric sites there was a primarily C_3 terrestrial diet and no evidence for significant consumption of marine food or C_4 plants such as millet.[90] The only exceptions for marine consumption were the high-status individuals buried within Grave Circles A and B at Mycenae, where there was clear evidence for such consumption, perhaps of up to 20–25% for some individuals.[91] Vika Aravantinos and Richards[92] suggest that the increased nitrogen values in humans from Classical Thebes (some 5‰ higher $\delta^{15}N$ values than the prehistoric data) are possibly indicative of freshwater fish consumption, and found support for this idea in the documentary evidence of the era. Finally, a study that investigated the breastfeeding and weaning patterns of the Bronze Age population of Lerna suggests that weaning must have started at or before the age of 2.5 years to 3 years. Interestingly, in the same study one 4-year-old individual provided evidence for late weaning, with very positive $\delta^{13}C$ and $\delta^{15}N$ values ($\delta^{13}C$ value: -19.1‰; $\delta^{15}N$ value: 9.2‰).[93]

Isotopic Analysis of Byzantine Populations

Materials and Methods

Stable isotope analysis has proved to be a useful tool for the reconstruction of Byzantine diet and attitudes toward breastfeeding and weaning.[94] In this section all available data from nine sites in Greece are brought together in order to present as complete a picture as possible of diet and weaning patterns for the period in question.[95] Together these studies offer information on the diets and weaning

89 Papers presented at this session and additional contributions will appear in a forthcoming volume of the Occasional Wiener Laboratory Series (OWLS).

90 A case of, most likely, millet consumption is suggested for a single adult individual from Kalamaki as evidenced by the enriched $\delta^{13}C$ values; Richards and Vika 2008.

91 Richards and Hedges 1999, 2008; and see the discussion on the archaeology of fishing in the Bronze Age Aegean in Mylona 2008b, 11–12.

92 Vika, Aravantinos and Richards 2009.

93 Triantaphyllou et al. 2008.

94 Data on trace element analysis are available for the populations of Gortyn in Crete – Fornaciari, Ceccanti and Menicagli 1988; and Korytiani in Epirus – Georgakopoulou and Xirotiris 2009, 211–15; however, due to the limitations inherent in this type of analysis and since only stable isotope data will be discussed here, these studies are excluded.

95 An initial attempt to survey all available isotopic data for Byzantine populations is presented in the paper by Bourbou and Garvie-Lok forthcoming, where the isotopic data from five sites in Greece (Abdera, Kastella, Nemea, Petras and Servia) are discussed.

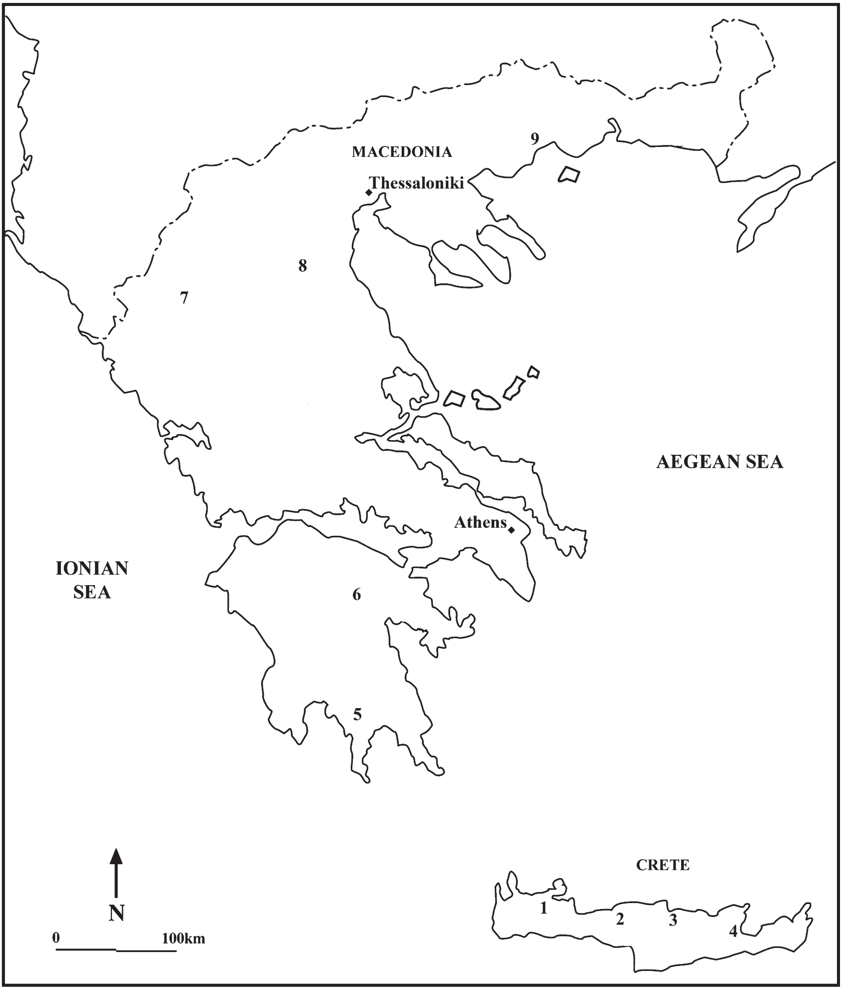

Figure 4.1 Map of sites from which bone samples are taken

Key: 1=Stylos; 2=Eleutherna; 3=Kastella; 4=Petras; 5=Messene; 6=Nemea; 7=Sourtara; 8=Servia; 9=Abdera

patterns of Byzantine communities in Greece from both inland and coastal areas, between which some variation in available resources likely existed (Table 4.2 and Figure 4.1). Garvie-Lok was the first to analyze bone collagen and carbonate from three middle Byzantine sites, as part of a wider study on diet in medieval and early modern Greece.[96] In 2004 the author, together with M.P. Richards at the University of Bradford (UK), instituted a project for stable isotope analysis of Byzantine Greek populations. This project is currently continuing at the Max Planck Institute for Evolutionary Anthropology (Germany), with the essential contribution of B.T. Fuller.

Table 4.2 Sites from which samples for stable isotope analysis have been taken

Site	Date	Type	Reference
Abdera	Sixth–ninth centuries AD and twelfth–thirteenth centuries AD	Coastal	A. Agelarakis pers. comm. 2007
Eleutherna	Sixth–seventh centuries AD	Inland	Bourbou, Fuller and Richards 2008[1]
Kastella	Eleventh century AD	Coastal	Bourbou and Richards 2007
Messene	Sixth–seventh centuries AD	Inland	Bourbou, Fuller and Richards 2008[1]
Nemea	Twelfth–thirteenth centuries AD	Inland	Garvie-Lok 2001
Petras	Twelfth–thirteenth centuries AD	Coastal	Garvie-Lok 2001
Servia	Eleventh–fifteenth centuries AD	Inland	Garvie-Lok 2001
Sourtara	Sixth–seventh centuries AD	Inland	Bourbou, Fuller and Richards 2008[1]
Stylos	Eleventh-twelfth centuries AD	Inland	Bourbou, Fuller and Richards 2008[1]

[1] Project on the investigation of Byzantine dietary patterns conducted at the Max Plank Institute (2007–09)

Samples of bone were collected mainly from ribs and long bones, and collagen was purified from these for analysis. Human bone collagen was extracted from the material recovered at Eleutherna, Kastella, Messene, Sourtara and Stylos following a modified Longin procedure,[97] as outlined in detail elsewhere,[98] with the addition of an ultrafiltration step.[99] Isotopic values for the Kastella samples were measured using a Carlo Erba elemental analyzer coupled to a ThermoFinnigan Delta Plus XL mass spectrometer at the Isotope Laboratory, Department of Archaeological Sciences, University of Bradford. Isotopic values for the samples from Eleutherna, Messene, Sourtara and Stylos were measured using a ThermoFinnigan elemental analyzer coupled to a ThermoFinnigan Delta Plus XL mass spectrometer, at the Max Planck Institute for Evolutionary Anthropology, Department of Human Evolution.

96 Garvie-Lok 2001.
97 Longin 1971.
98 Richards and Hedges 1999.
99 Brown, Nelson and Southon 1988.

For the Servia, Petras and Nemea material, the ultrafiltration step was omitted, but the material was treated with NaOH to remove contaminants.[100] Collagen preservation was assessed from sample C:N ratios, following criteria outlined by DeNiro.[101] These remains were analyzed at the Stable Isotope Laboratory of the University of Calgary (Canada), Department of Physics and Astronomy, using an NA 1500 elemental analyzer coupled to a Finnigan Mat TracerMat mass spectrometer. Stable isotope analysis of associated fauna was restricted to the available material from Eleutherna, Kastella and Sourtara.[102]

The attempted reconstruction of dietary and weaning patterns in Greek Byzantine populations was based on both indirect and direct evidence. Indirect evidence included information extracted from documentary sources, as reviewed above, and from the study of specific pathological conditions, such as dental diseases and metabolic disorders. Direct evidence included data derived from stable isotope analysis, which focused on: (1) the relative importance of animal products to the general diet; (2) the importance of marine resources and C_4 grains to the diet; (3) the possible differential access to food by gender; and (4) the reconstruction of breastfeeding and weaning patterns.

The Results of the Analysis

Table 4.3 shows the stable isotope values for the human bone samples, analyzed by the author, from the sites of Eleutherna, Kastella, Messene, Sourtara and Stylos. The adult isotopic values of the samples from these sites are graphically represented in Figure 4.2, which also includes the available data from the sites of Abdera,[103] Nemea, Petras and Servia.[104] Table 4.4 shows the isotopic values for the animal bone samples used for analysis from the sites of Eleutherna, Kastella and Sourtara. Adult and fauna values are graphically presented in Figure 4.3.[105]

100 Katzenberg and Weber 1999.

101 DeNiro 1985.

102 Garvie-Lok's data include all faunal samples that provided collagen, independent of time period. For example, as fish remains were not included in the faunal samples, modern Aegean fish caught in Aegean or Adriatic waters were used. The fish were purchased fresh from the Athens central market and processed for collagen extraction as appropriate.

103 A. Agelarakis pers. comm. 2007.

104 Garvie-Lok 2001.

105 Also included are stable isotope values of animal bones from Mitilini (island of Lesvos), Corinth and Athens; Garvie-Lok 2001.

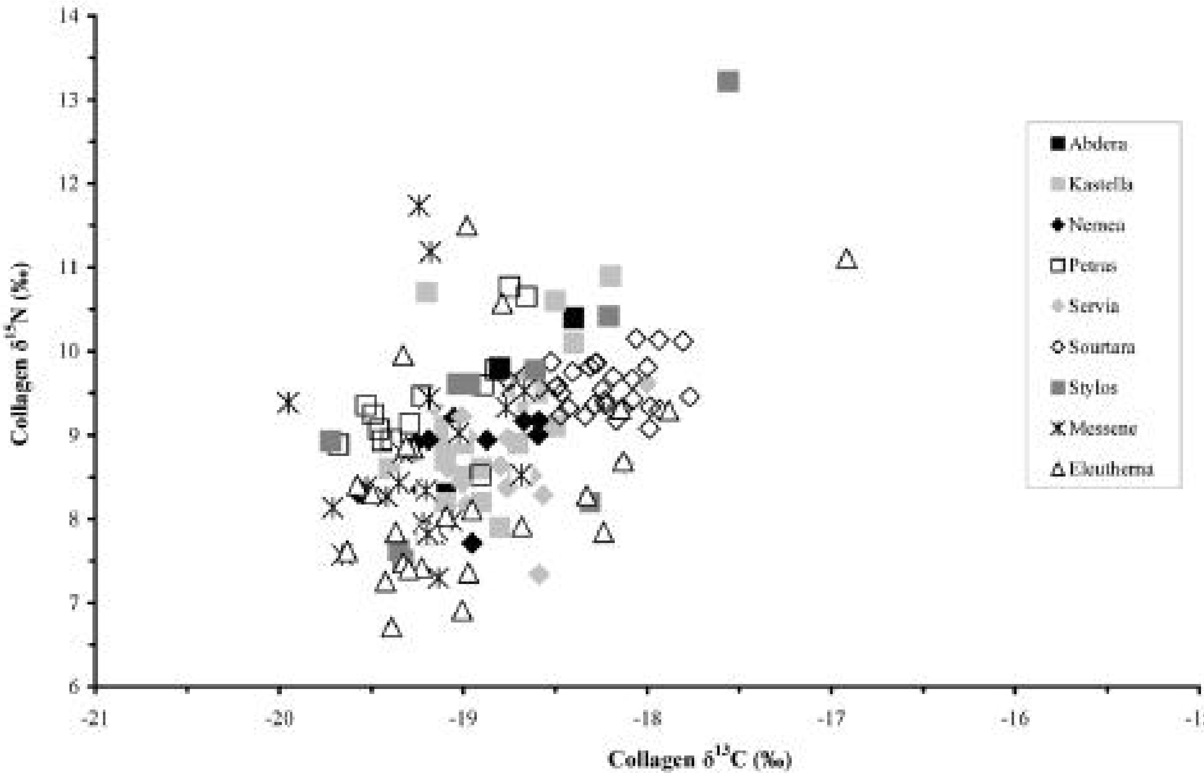

Figure 4.2 $\delta^{13}C$ and $\delta^{15}N$ values of the adult samples

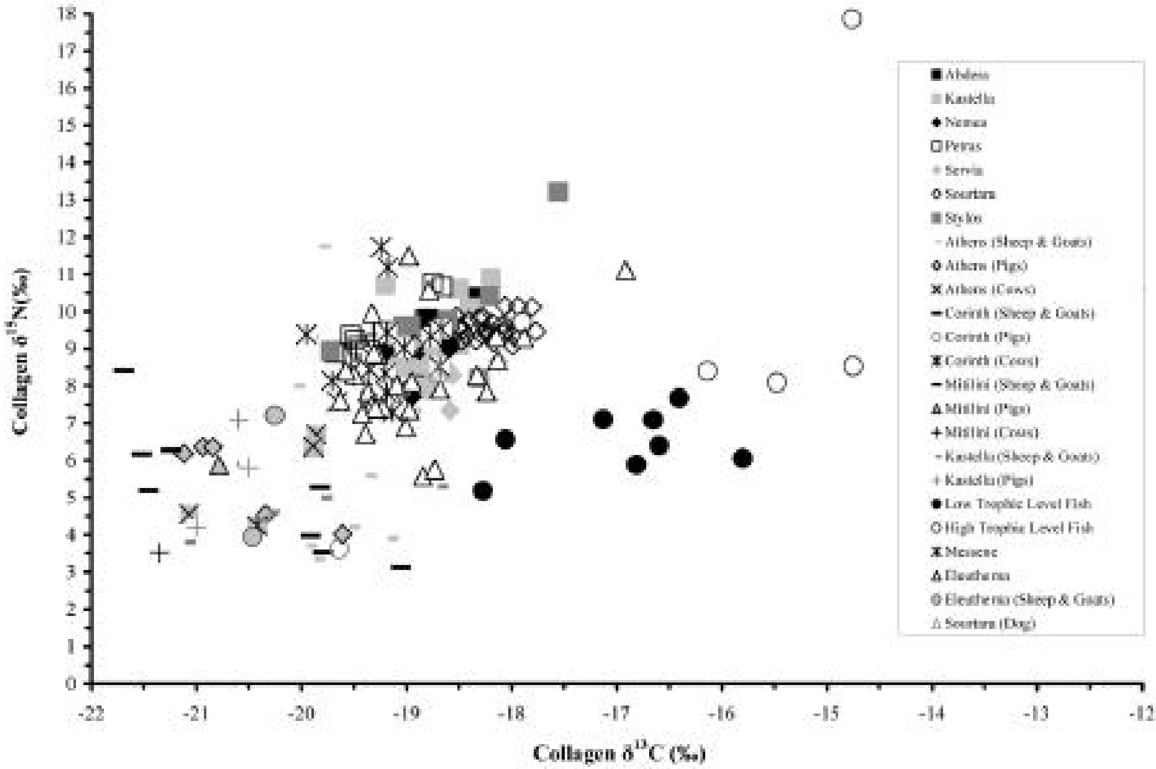

Figure 4.3 δ[13]C and δ[15]N values of the adult and fauna samples

Table 4.3 Stable isotope values for the human bone samples from Eleutherna, Kastella, Messene, Sourtara and Stylos

Sample no.	Skeleton no.	Burial	Sex	Age	$\delta^{13}C$	$\delta^{15}N$	C:N	%C	%N	% Yield
Eleutherna										
#39	013a	31	F	24	-18.8	5.6	3.1	43.4	16.4	1.1
#24	017b	42	M	25	-18.7	7.9	3.3	40.3	14.2	1.3
#36	011a	8	M	30	-19.3	8.8	3.3	41.3	14.5	2.6
#30	014a	34	M	35	-19.0	7.4	3.2	41.5	15.0	5.7
#41	028a	27	M	35	-18.3	8.3	3.3	39.4	13.9	1.8
#6	026a	20	M	35.2	-19.5	8.3	3.5	38.7	12.9	1.3
#7	035b	48	F	54	-19.4	6.7	3.3	40.0	14.3	1.5
#48	035a	48	F	54	-18.1	9.3	3.3	33.9	12.1	3.7
#21	019	36	F	59	-19.1	8.0	3.4	40.9	14.1	2.9
#17	016g	40	?	15 years ± 36 months	-19.0	11.5	3.6	35.7	11.7	1.4
#14	005th	18	M	17–25	-19.2	7.4	3.3	37.3	13.7	4.1
#29	021	9	F	17–25	-19.4	7.8	3.5	36.3	12.1	3.8
#32	010a	6	F	17–25	-18.8	10.6	3.4	39.3	13.5	5.1
#47	015a	33	M	17–25	-18.1	8.7	3.3	38.0	13.6	2.4
#5	005ist	18	M	25–35	-19.3	7.5	3.2	37.3	13.7	1.9
#28	036a	47	M	25–35	-19.3	8.9	3.4	40.4	13.8	1.7
#46	002b	17	M	25–35	-19.6	7.6	3.2	34.5	12.7	1.9
#23	017a	42	F	27–30	-19.3	7.4	3.0	41.1	15.8	2.0
#25	024	44	F	30–35	-18.2	7.8	3.3	40.5	14.4	5.4
#3	023a	11	F	31–35	-19.4	7.3	3.3	20.1	7.2	2.0
#16	005b	18	M	33–45	-19.0	8.1	3.2	40.7	14.7	4.9
#33	010b	6	M	33–45	-19.3	9.9	3.5	43.1	14.4	4.1
#42	007	19	M	33–45	-16.9	11.1	3.2	40.3	14.5	4.7
#31	005ke	18	M	45+	-19.6	8.4	3.6	37.6	12.2	2.1
#40	012b	32	M	45–49	-18.7	5.8	3.0	37.8	14.6	5.9
#43	006g	41	F	adult	-17.9	9.3	3.2	37.9	13.6	6.1
#45	002a	17	F	adult	-19.0	6.9	3.3	39.1	13.9	2.3
Kastella										
#1	001	4	F	c. 25	-18.7	9.4	3.3	45.2	15.8	6.2
#2	002	1	M	30–35	-18.6	9.5	3.3	46.1	16.4	6.5
#3	003	7	M	adult	-18.5	10.6	3.3	40.1	14.1	3.0
#4	004	6	M	50	-18.7	8.9	3.3	39.2	13.9	1.6
#5	009	11	M	adult	-18.2	10.9	3.3	30.2	10.8	1.4
#6	012	12	M	31	-18.9	8.2	3.3	20.0	7.1	1.6
#7	013	16	M	44	-19.1	9.0	3.3	40.0	14.2	2.2
#8	014	15	M	39	-19.1	8.8	3.4	45.5	15.7	1.0
#9	015	17	F	35–40	-19.1	9.1	3.3	47.1	16.5	3.0
#10	016	18	F	24	-19.1	8.7	3.3	42.0	14.8	3.4
#11	023	27	F	50–60	-18.9	8.6	3.3	44.7	15.8	6.5
#12	025	29	F?	adult	-19.2	7.8	3.4	40.1	13.9	2.2
#13	022	24	M	35	-19.4	8.6	3.3	44.1	15.4	4.3
#14	017	20	M	35–40	-18.4	10.1	3.4	36.8	12.8	0.5
#15	019a	21	M?	adult	-19	8.5	3.3	37.0	13.2	5.9
#S6	021	25	?	12 years ± 36 months	-19.3	8.8	3.3	37.5	13.3	2.2
#S5	020	26	?	15 years ± 36 months	-19.2	10.7	3.3	31.6	11.1	0.7

Sample no.	Skeleton no.	Burial	Sex	Age	δ13C	δ15N	C:N	%C	%N	% Yield
#S7	027	32	?	15 years ± 36 months	-18.5	9.1	3.3	32.3	11.6	3.3
#S9	026	30	?	15 years ± 36 months	-19.1	8.2	3.3	42.0	14.8	3.0
Messene										
#26	069	73	?	16	-19.1	8.0	3.4	34.9	12.0	1.2
#9	020	2(1991)	M	18	-18.7	9.5	3.4	38.7	13.4	3.9
#23	059	33	M	19	-19.1	7.3	3.4	38.0	13.2	1.8
#13	035	38	M	24	-19.2	11.7	3.5	40.2	13.3	1.4
#20	054	29	M	27	-19.3	8.8	3.4	29.1	10.0	2.0
#2	002	11	M	28	-19.2	7.9	3.4	38.0	13.2	1.7
#6	016	3	M	30	-19.2	8.3	3.4	39.3	13.5	2.6
#7	018	6	F	30	-19.2	7.8	3.3	40.0	14.1	3.3
#8	019	6	M	30	-19.2	9.4	3.4	37.3	12.9	2.2
#1	001	12	M	35	-19.2	11.2	3.6	41.3	13.5	2.7
#15	047	28	F	35	-19.4	8.3	3.4	41.2	14.2	2.4
#18	051	32	F	35	-19.5	8.4	3.5	34.8	11.7	0.9
#19	052	35	M	35	-18.7	8.5	3.2	34.6	12.5	1.6
#10	023	1(1991)	F	39	-19.1	7.9	3.3	23.2	8.2	1.9
#14	040	14	M	40	-20.0	9.4	3.6	35.9	11.6	2.5
#3	004	10	M	44	-19.0	9.0	3.3	41.4	14.6	2.0
#16	048	28	M	44	-19.4	8.4	3.6	38.6	12.6	2.4
#27	070	73	M	44	-19.2	7.8	3.4	37.8	13.1	1.1
#25	067	66	M	45	-19.7	7.6	3.4	35.8	12.4	1.7
#21	057	1(1995)	?	15 years ± 36 months	-19.7	8.1	3.5	33.2	11.1	3.3
#22	058	38	F	adult	-18.8	9.3	3.4	36.4	12.4	2.9
Sourtara										
#31	090	97	?	12 years	-17.8	10.1	3.2	38.7	14.1	4.4
#22	081	15	?	child	-18.1	9.7	3.2	40.3	14.7	2.8
#26	085	107	M	<18	-18.8	9.6	3.3	41.6	14.8	2.7
#27	086	24	F	<18	-18.3	9.2	3.2	36.1	13.1	1.0
#15	071	85	M?	c. 18	-18.4	9.3	3.2	41.5	15.0	2.7
#42	100	55	M?	24	-18.3	9.8	3.2	40.1	14.6	4.2
#1	001	78	F	31	-18.5	9.6	3.2	41.9	15.4	1.8
#5	038	37	M	35	-18.2	9.2	3.2	36.6	13.2	1.4
#6	020	63	F	35	-17.9	10.1	3.2	41.9	15.3	1.5
#17	076	93	F	35	-18.0	9.3	3.2	38.7	14.1	3.1
#4	039	95	F	39	-18.3	9.4	3.2	41.7	15.2	1.6
#9	074	25	M	42	-18.2	9.4	3.2	41.4	14.9	1.9
#18	077	89	M	44	-17.9	9.3	3.2	37.3	13.6	2.2
#7	021	22	M	c. 45	-18.2	9.5	3.2	41.9	15.2	1.9
#24	083	108	M	50	-18.2	9.7	3.3	39.1	14.0	2.6
#32	091	104	M	50	-18.5	9.2	3.2	34.9	12.6	2.0
#3	024	62	M	51	-18.4	9.8	3.2	40.1	14.7	1.3
#2	014	56	M	56	-18.1	9.4	3.2	41.9	15.1	1.1
#38	096	82	M	18–30	-18.3	9.9	3.2	43.3	15.7	3.6
#33	092	5	M	adult	-18.7	9.5	3.3	38.4	13.5	1.3
#35	093	90	?	adult	-18.0	9.8	3.2	40.7	14.9	4.1
#39	097	98	M	31–40	-17.8	9.5	3.2	42.8	15.5	5.9
#36	094	61	M	41–50	-18.1	9.3	3.2	30.8	11.2	0.8
#37	095	101	M	41–50	-18.2	9.4	3.2	41.6	15.1	3.5
#40	098	60	F	63	-18.0	9.1	3.2	40.7	14.7	2.9

Sample no.	Skeleton no.	Burial	Sex	Age	δ13C	δ15N	C:N	%C	%N	% Yield
#41	099	110	F	63	-18.3	9.9	3.3	42.2	14.9	3.9
#25	084	57	M	41–50	-18.5	9.5	3.3	42.0	15.1	2.6
Stylos										
#1	023a	1	F	30–35	-19.7	8.9	3.4	41.3	14.1	2.7
#2	003a	*	M	31–40	-19.3	7.5	3.3	41.1	14.8	3.3
#3	003a	*	F	31–40	-18.2	10.4	3.3	42.3	15.1	1.2
#4	012a	6	M	40–45	-19.0	9.6	3.3	29.6	10.6	2.0
#5	026a	*	M	31–40	-17.6	13.2	3.3	41.4	14.8	2.4
#6	001	*	F	31–40	-18.3	8.2	3.2	42.5	15.6	1.7
#7	001	*	F	31–40	-19.4	7.6	3.2	39.4	14.4	4.2
#8	007	21	M	41–50	-18.6	9.8	3.2	42.1	15.5	2.0
#9	028	22	M	51+	-19.0	9.6	3.3	35.4	12.6	1.9
#11	015	1(1990)	?	14.6–17.0 years	-20	8.3	3.4	30.1	10.4	2.5

Table 4.4 Stable isotope values for the animal bone samples from Eleutherna, Kastella and Sourtara

Species	δ13C	δ15N	C:N	%C	%N	% Yield
Eleutherna						
Sheep	-20.2	7.2	3.3	30.6	10.9	4.4
Sheep	-20.5	3.4	3.3	37.2	13.2	3.5
Kastella						
Sheep	-20.6	5.9	3.4	41.3	14.3	1.6
Red deer	-21.0	4.6	3.4	39.6	13.8	1.3
Pig	-21.0	4.2	3.4	8.6	3.0	0.5
Pig	-20.6	7.1	3.4	39.4	13.6	0.1
Pig (young)	-20.5	5.8	3.3	40.8	14.5	3.1
Goat	-18.7	5.3	3.3	37.6	13.2	1.9
Goat	-21.1	3.8	3.3	36.0	12.6	2.2
Goat	-20.3	4.6	3.3	39.5	14.0	2.1
Goat	-20.4	4.4	3.3	38.0	13.6	1.6
Goat	-19.8	5.0	3.3	37.0	13.2	4.9
Sourtara						
Dog	-18.7	8.38	3.3	34.9	12.2	2.8
Goat	-20.7	2.58	3.2	40.0	14.6	9.1

Despite possible dietary variations between inland and coastal sites, the stable isotope values of the human remains from the various sites are broadly similar (Table 4.5). Collagen shows mean $\delta^{13}C$ values ranging from -18.2 ± 0.3‰ at Sourtara to -19.2 ± 0.3‰ at Petras and mean $\delta^{15}N$ ranging from 8.2 ± 1.4‰ at Eleutherna to 9.5 ± 1.1‰ at Abdera. Bone carbonate values, while not measured from all of the sites, are also rather homogeneous, ranging from -10.7 ± 1.2‰ at Nemea to -11.2 ± 0.9‰ at Abdera (Figure 4.4).

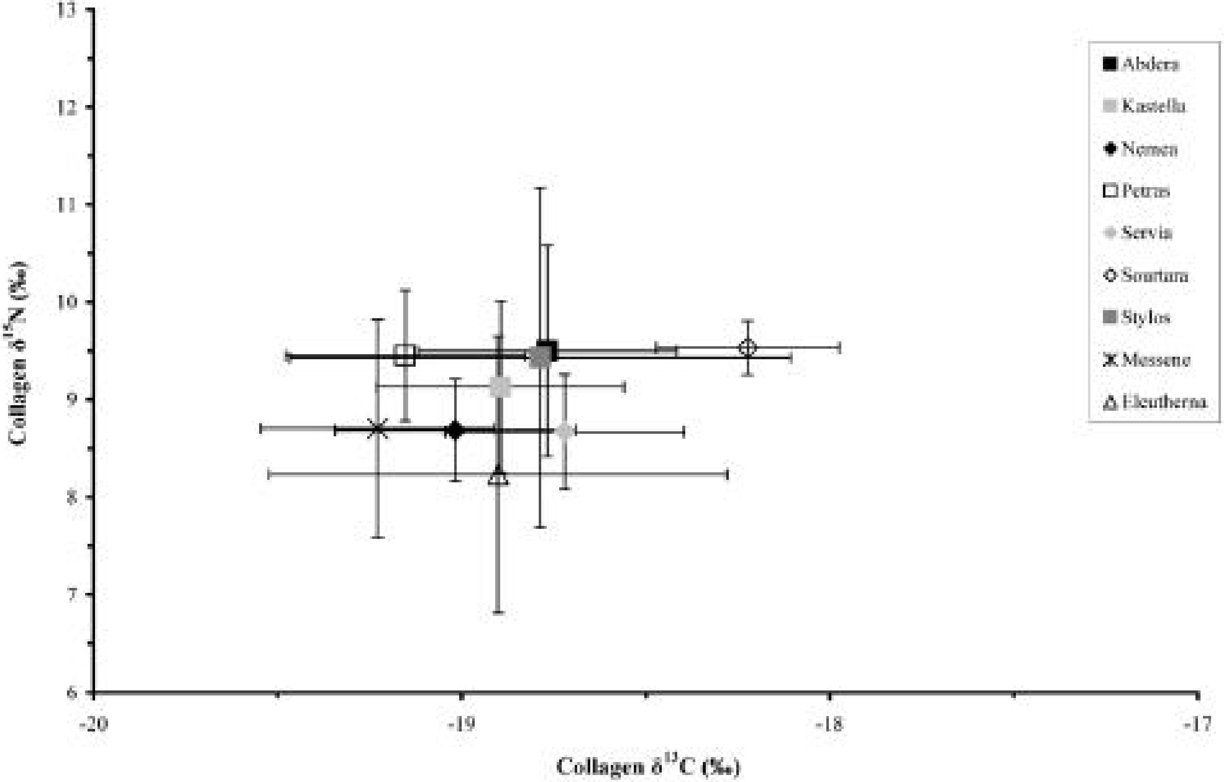

Figure 4.4 Average $\delta^{13}C$ and $\delta^{15}N$ values of the adult samples

Table 4.5 Average adult human stable isotope values by site

Site	$\delta^{13}C_{coll}$ (‰PDB)	$\delta^{15}N$ (‰AIR)	$\delta^{13}C_{carb}$ (‰PDB)
Abdera	-18.8 ± 0.4	9.5 ± 1.1	-12.8 ± 0.8
Eleutherna	-18.9 ± 0.6	8.2 ± 1.4	-
Kastella	-18.8 ± 0.3	9.1 ± 1.2	-
Messene	-19.2 ± 0.3	8.7 ± 0.9	-
Nemea	-19.0 ± 0.3	8.7 ± 0.5	-11.2 ± 0.9
Petras	-19.2 ± 0.3	9.5 ± 0.7	-12.0 ± 0.7
Servia	-18.7 ± 0.3	8.7 ± 0.6	-11.9 ± 0.6
Sourtara	-18.2 ± 0.3	9.5 ± 0.3	-
Stylos	-18.8 ± 0.7	9.4 ± 1.7	-

These human collagen values, when plotted with values for some Byzantine-era domesticated fauna and modern Aegean fish, fall in a tight cluster where $\delta^{13}C$ and $\delta^{15}N$ values are generally elevated over the domesticates (Figure 4.5). If we consider the diverse foods available to Byzantine populations, and the wide range of likely $\delta^{13}C$ and $\delta^{15}N$ values estimated above for these resources, the $\delta^{13}C$ and $\delta^{15}N$ differences between these nine human populations are relatively small. Isotopic data also demonstrate no differential access to food products by gender, although the paleopathological data and written sources attest otherwise. For example, dental pathologies affect more males than females, while a close association between fasting and sexual abstinence, targeting females, is highlighted in various sources of the early Christian tradition (see above) (Figure 4.6).

The stable isotope analysis seems to suggest the existence of a general 'Byzantine diet' that was broadly similar between communities, although it may have varied somewhat by location. Such a scenario agrees with the documentary sources, reviewed above, that suggest a fundamental reliance on a trio of staples – grain, oil and wine – that were supplemented, depending on class and other variables, by other foods. The $\delta^{13}C$ results indicate that the diet was predominately based on C_3 terrestrial foods, but there is some evidence to suggest that C_4 grains and marine protein resources were also consumed at some of the sites. The inland site of Sourtara has a range of 2‰ in $\delta^{13}C$ values but shows little change in the $\delta^{15}N$ values, which suggests that the population consumed some domesticated animals that had a C_4 component in their diet. However, substantial dependence on a C_4 grain staple, such as millet, is not indicated at any of the sites. Consumption of marine protein resources is seen at the coastal sites and for some individuals from the inland sites, and will be discussed in more detail below.

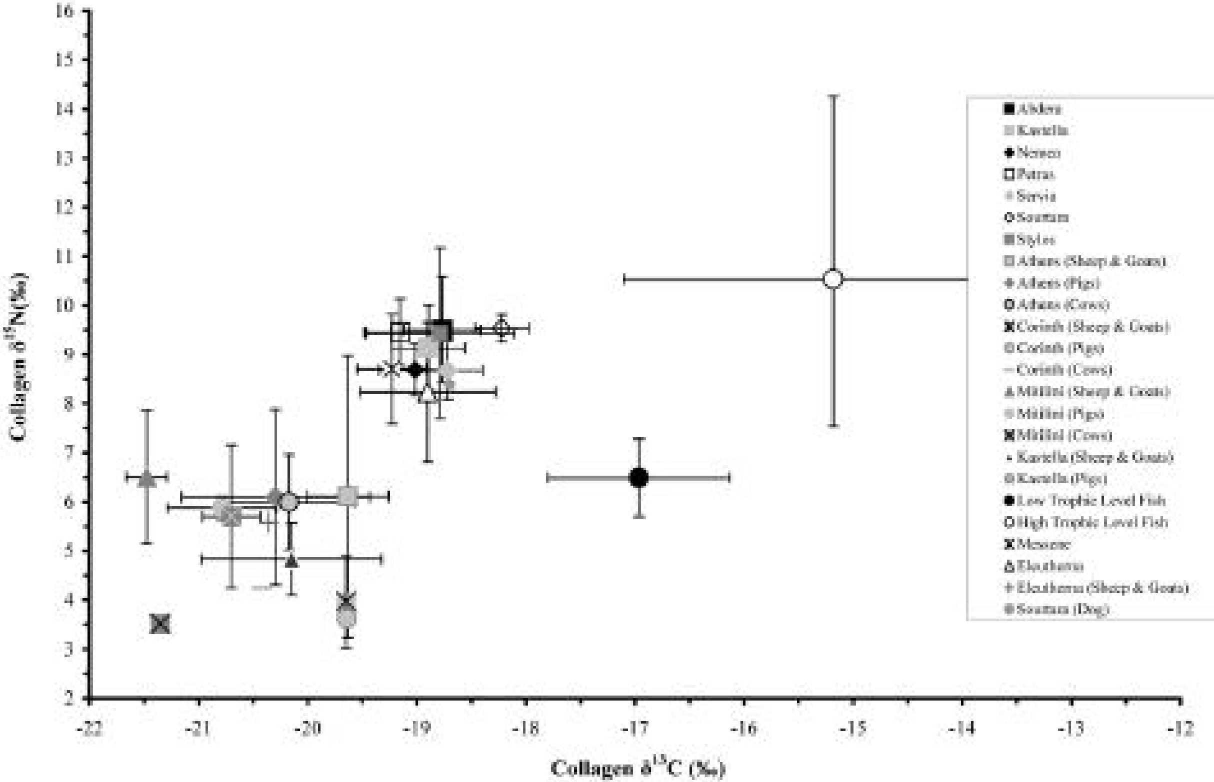

Figure 4.5 Average $\delta^{13}C$ and $\delta^{15}N$ values of the adult and fauna samples

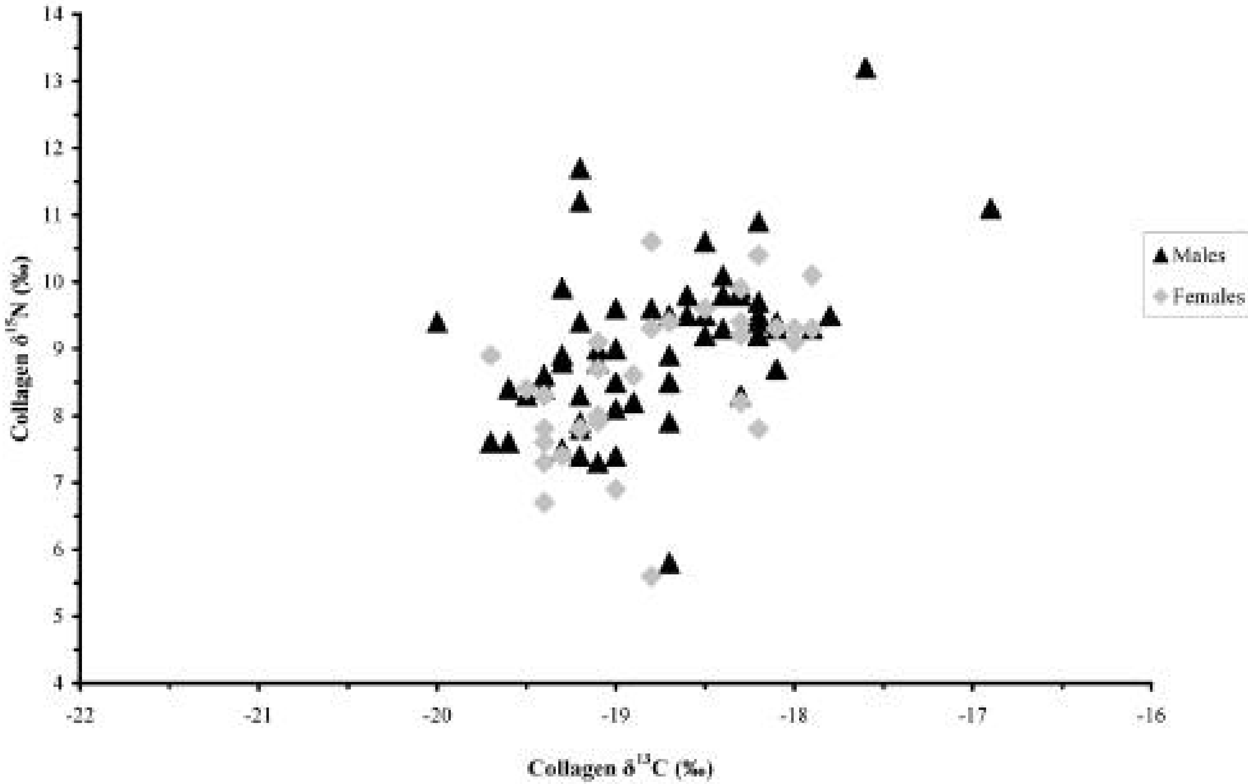

Figure 4.6 Male and female $\delta^{13}C$ and $\delta^{15}N$ values for all sites

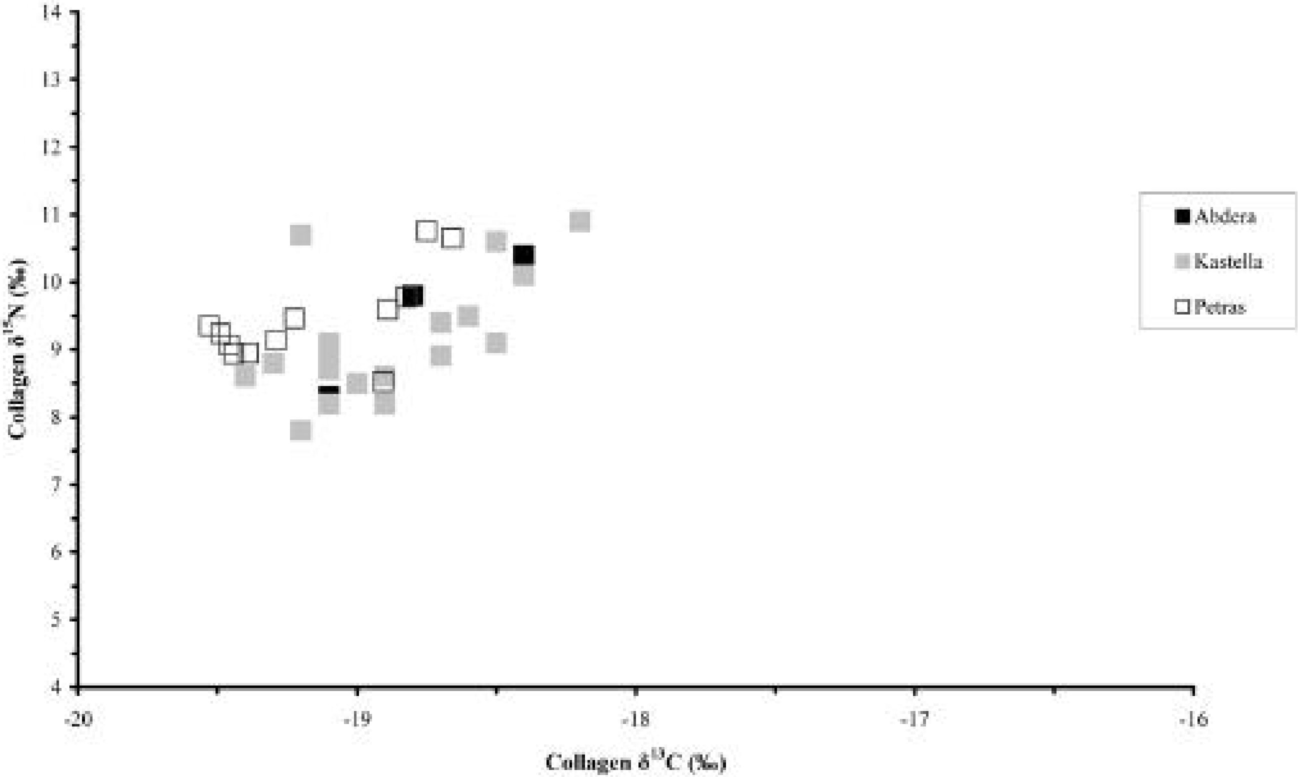

Figure 4.7 $\delta^{13}C$ and $\delta^{15}N$ values of the coastal sites of Abdera, Kastella and Petras

Variation in the consumption of resources such as C_3 and C_4 grains, animals (pigs vs. sheep and goats) and olive oil might explain the minor site-to-site differences seen in the average carbonate $\delta^{13}C$. Another potential source of variation may lie in the consumption of oily fish. The estimated bulk dairy $\delta^{13}C$ value used here is similar to the C_3 plant value and reflects the generally C_3-based diet of goats and sheep sampled to date for Byzantine sites. Within this scenario the addition of dairy foods would not be expected to shift bulk diet $\delta^{13}C$ away from the C_3 grain value.

The $\delta^{15}N$ values obtained are similar to those seen for many other European agricultural populations with respect to their substantial elevation above domesticated fauna.[106] Collagen values are ^{13}C-enriched compared to the domesticates, and ^{13}C-depleted compared to the marine resources. These results are indicative of a general diet in which most dietary protein came from domesticated fauna, with some input from marine resources. Increasing marine resource consumption causes enriched ^{13}C and ^{15}N ratios in human tissues such as hair and bone.

A closer look at the data on an individual level offers support for increased marine protein consumption at some of the sites.[107] Figure 4.7 shows data for the coastal sites of Abdera, Kastella and Petras. Here a number of individuals can be seen to stand apart from the majority, with a tendency toward the higher $\delta^{13}C$ and $\delta^{15}N$ values as expected for the consumption of marine resources. This pattern reflects some use of marine resources at these sites (a reasonable conclusion given their location), but this pattern is also evident at the inland sites (Figure 4.8). The two individuals who show evidence for the largest consumption of marine protein resources are both from inland sites. Skeleton 007 from Eleutherna has the most enriched ^{13}C value (-16.9‰) of all the individuals from the nine populations studied, as well as an elevated $\delta^{15}N$ value (11.1‰), and this indicates that a significant portion of the diet came from marine protein resources. In addition, the individual of burial 26a from Stylos displays the highest $\delta^{15}N$ value (13.2‰) of all the populations and the second most enriched ^{13}C value (-17.6‰), again indicating a diet heavily based on marine proteins.[108]

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106 Van Klinken, Richards and Hedges 2000; Privat, O'Connell and Richards 2002; Polet and Katzenberg 2003; Prowse et al. 2004; Müldner and Richards 2005; Dürrwachter et al. 2006; Jay and Richards 2006; Keenleyside, Schwarcz and Panayotova 2006; Richards, Fuller and Molleson 2006.

107 Garvie-Lok 2001; Bourbou and Richards 2007. To eliminate the confounding effects of breastfeeding, individuals aged less than 3 years are not shown in these figures.

108 The isotopic values and thus the diets of these individuals differ significantly from those of the other individuals in the population, and the distinction could suggest that they were migrants.

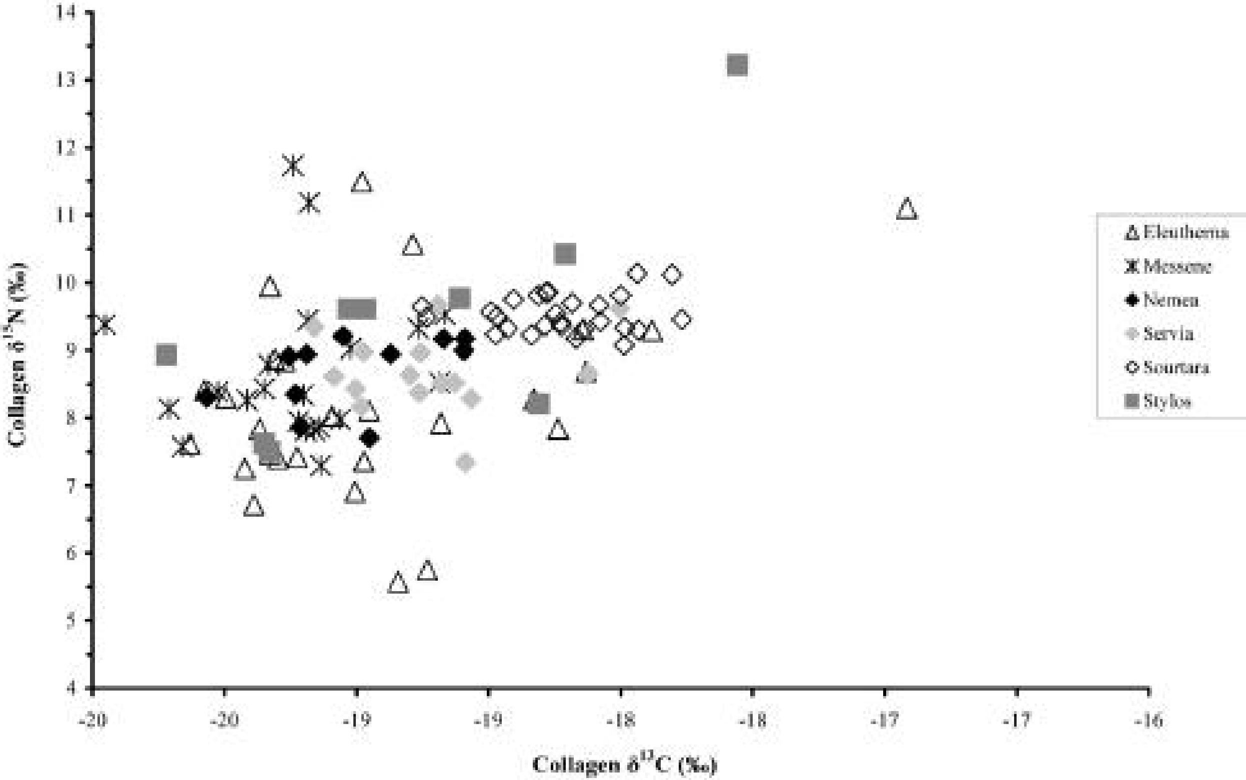

Figure 4.8 $\delta^{13}C$ and $\delta^{15}N$ values of the inland sites of Eleutherna, Messene, Nemea, Servia, Sourtara and Stylos

This finding of the consumption of marine species during the Byzantine period contrasts with previous isotopic studies of prehistoric coastal populations that found marine species contributing little or not at all to the diet.[109] The Byzantines were well aware that fish and most of the aquatic animals constituted a food source of high nutritional value, and they had perhaps developed specific fishing methods for the various species. Another possible explanation for the contrast in use of marine protein resources is that fasting rules contributed to the increased consumption of fish and aquatic species in the Byzantine era.[110] Ultimately, the major differences in time, customs and technology separating the prehistoric and Byzantine periods disallow the drawing of any direct parallels between prehistoric and Byzantine diets; but stable isotope data broadly suggest that both inland and coastal populations during the Byzantine period supplemented an essentially land-based C_3 diet with some possible C_4 and marine resources. Consumption of marine resources is possibly expected at the coastal sites, given their location, and at the inland sites freshwater fishes could have been consumed where lakes and rivers existed (as, for example, at the site of Stylos with its numerous springs of fresh water). Freshwater fishes are attested in the written sources and are known to have been consumed (see above).[111] Until more material is available, such as fish bones from the Byzantine period of Greece that can be isotopically analyzed, explanations for the consumption of fish and aquatic species in Byzantine Greece remain tentative.[112]

Although intra-site patterning of collagen values indicates that some marine exploitation occurred both at inland and coastal sites, sources other than marine protein could have contributed to some of the generally high collagen $\delta^{15}N$

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[109] For example, although none of the Neolithic groups studied by Papathanasiou 2003 had a strong dependence on marine resources, the diets of the Franchthi and Kephala populations included significant amounts of such foods.

[110] For example, fasting rules allow for the consumption of fish during the Lenten period of Christmas; on the Transfiguration feast day (6 August) that is included in the fasting period for the Assumption of the Virgin Mary on August 15; and on the feast of the Annunciation (25 March) that is included in the Lenten period of Easter. In addition, the consumption of all seafood other than fish is allowed in all the fasting periods. The contribution of fasting regulations imposed by the Church are also implied as a possible factor for the increase of marine protein in later medieval diet; see, e.g., Müldner and Richards 2005, 45–6; 2007a, 695; 2007b, 168.

[111] Richards, Fuller and Hedges 2001 suggest that the application of $\delta^{34}S$ analysis has the potential to distinguish consumers of freshwater fish from consumers of terrestrial foods; see also Privat, O'Connell and Hedges 2007.

[112] Fish-bone collagen recovered from prehistoric to classical sites is currently under analysis for $\delta^{13}C$ and $\delta^{15}N$ values in an investigation of the extent of fish consumption in Greek antiquity; E. Vika pers. comm. 2009.

values seen at Byzantine sites such as Messene and Eleutherna. Recent work by Bogaard and colleagues suggests that high $\delta^{15}N$ values in some European agricultural communities may reflect elevated grain $\delta^{15}N$ due to the manuring of fields.[113] This model, however, may not apply to the Byzantine agricultural system. Although domesticates did graze on cleared fields, and would thus have deposited some manure there, they were often kept for much of the year on land remote from cultivated fields, which made their dung unavailable for fertilizer during this period.[114]

Other explanations for high $\delta^{15}N$ values at some Byzantine sites fit well with documentary evidence for the Byzantine diet. It has been suggested, for example, that high $\delta^{15}N$ values of European agricultural populations may in some cases reflect a very heavy reliance on dairy foods.[115] This scenario agrees with the importance of dairy foods in the Byzantine diet as attested in the documentary sources. Given the low cost of some dairy foods and their general availability, use of dairy foods is an attractive explanation for the generally high $\delta^{15}N$ values seen in Byzantine groups studied to date. It is also possible that high $\delta^{15}N$ values in Byzantine populations reflect consumption of dietary items of unexpectedly high $\delta^{15}N$ values, such as chickens, chicken eggs and suckling animals.[116]

Stable isotope data also provide some tentative information on weaning practices in Byzantine Greece.[117] The stable nitrogen isotope data for non-adults from Eleutherna, Kastella, Messene, Sourtara and Stylos are presented in Table 4.6. Table 4.7 presents $\delta^{15}N$ values and female mean for the samples of Nemea, Petras and Servia. The fact that the samples represent several sites complicates the interpretation of the data, as the stable $\delta^{15}N$ values for the typical adult female vary among sites, reflecting local variation in diet. The data are more easily interpreted when each non-adult value is considered in terms of its relationship to the mean adult female value for its site. This format essentially standardizes the non-adult values in terms of their elevation relative to adult female values from the same site.

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113 Bogaard et al. 2007.

114 Kazhdan 1997.

115 Hedges and Reynard 2007.

116 Garvie-Lok 2001. Because foraging chickens consume many insects, their flesh and eggs show $\delta^{15}N$ values above those of herbivores; see, e.g., Schwarcz 1999.

117 See Bourbou and Garvie-Lok 2009.

Table 4.6 Non-adult $\delta^{15}N$ values and adult female mean for Eleutherna, Kastella, Messene, Sourtara and Stylos

Sample no.	Skeleton no.	Burial	Sex	Age	$\delta^{13}C$	$\delta^{15}N$	C:N	%C	%N	% Yield
Eleutherna										
#8	035d	48	?	birth–3 years	-19.3	7.7	3.3	41.5	14.7	4.4
#9	035g	48	?	birth–3 years	-19.4	6.9	3.2	40.2	14.6	3.2
#12	005ia	18	?	18 months ±6 months	-19.2	10.8	3.5	39.5	13.4	1.1
#10	005e	18	?	2 years ±8 months	-19.9	7.0	3.3	38.6	13.7	1.0
#13	005i	18	?	3 years ±12 months	-18.9	11.4	3.6	39.9	12.9	1.5
#22	020e	37	?	5 years ±16 months	-19.1	8.1	3.6	40.8	13.3	1.7
#19	016a	40	?	6 years ±24 months	-19.1	11.7	3.5	37.6	12.5	2.4
#20	020g	37	?	6 years ±24 months	-19.0	9.2	3.5	40.2	13.6	4.1
#34	006ia	41	?	6 years ±24 months	-19.1	8.1	3.2	39.8	14.4	6.7
#1	003th	13	?	4–12 years	-19.4	7.0	3.2	41.2	14.9	3.3
#2	003h	13	?	4–12 years	-20.3	7.5	3.3	36.2	12.9	0.9
#35	006th	41	?	4–12 years	-19.0	7.9	3.5	24.3	8.2	2.9
#44	002st	17	?	4–12 years	-18.2	8.0	3.3	39.7	14.1	1.9
#26	036g	47	?	8 years ±24 months	-19.0	8.3	3.4	34.2	11.7	1.7
#4	005id	18	?	9 years ±24 months	-19.3	6.7	3.3	44.4	15.8	1.3
#27	036b	47	?	9 years ±24 months	-18.7	8.7	3.3	40.4	14.5	3.2
Adult female mean=7.4 ± 1.4										
Kastella										
#S1	016b	18	?	7 years ±24 months	-19.0	8.9	3.3	40.3	14.4	5.6
#S2	016d	18	?	2 years ±8 months	-18.0	12.1	3.2	40.8	14.7	6.3
#S3	016g	18	?	0.5 months–1.5 year	-18.3	11.6	3.3	33.0	11.7	3.0
#S4	016e	18	?	10 years ±30 months	-18.8	7.9	3.2	37.2	13.4	4.0
#S8	018	22	?	4.5–5.5 years	-18.7	8.3	3.2	26.5	9.8	1.9
#S10	018e	22	?	7.5–8.5 years	-18.7	8.5	3.3	38.2	13.7	2.6
#S11	024	28	?	4 years ±12 months	-19.4	7.5	3.4	46.5	15.8	1.4
Adult female mean=8.7 ± 0.6										
Messene										
#4	005	9	?	1–3 years	-18.9	8.5	3.4	39.7	13.8	3.3

#11	026	16	?	1–3 years	-19.6	8.7	3.3	39.2	13.7	1.3
#17	050	36	?	1–3 years	-20.4	7.6	3.5	34.6	11.5	1.2
#24	060	26	?	1–3 years	-18.9	7.2	3.4	29.6	10.2	4.7
#12	032	13	?	9.5–10.5 years	-18.9	7.1	3.3	41.3	14.5	1.1
Adult female mean=8.3 ± 0.6										
Sourtara										
#19	078	91	?	Birth–3 years	-17.6	11.0	3.2	41.3	15.1	3.8
#20	079	84	?	Birth–3 years	-16.9	12.1	3.2	42.5	15.5	4.5
#21	080	81	?	Birth–3 years	-17.2	10.2	3.2	42.6	15.5	5.1
#11	051	9	?	18 months ± 6 months	-18.0	12.0	3.3	42.1	14.8	3.6
#43	102	35	?	2 years	-17.5	11.0	3.3	32.5	11.5	0.7
#29	088	12	?	3–4 years	-18.4	10.6	3.2	40.2	14.5	2.2
#25	057	44	?	3 years ± 12 months	-18.4	10.2	3.4	37.3	12.7	2.6
#30	089	79	?	4–5 years	-18.1	9.6	3.2	42.2	15.4	1.8
#23	082	4	?	5–6 years	-18.5	9.5	3.2	39.9	14.4	3.3
#14	055	20	?	6 years ± 24 months	-18.4	9.5	3.2	41.9	15.1	2.1
#16	073	30	?	6 years ± 24 months	-17.7	9.5	3.2	42.4	15.4	5.5
#28	087	2	?	8–9 years	-18.7	9.7	3.3	37.8	13.5	1.7
#34	092a	5	?	9 years	-18.5	9.6	3.2	40.7	14.1	1.5
#8	047	21	?	10 years ± 30 months	-18.5	9.9	3.3	41.6	14.9	1.9
#10	075	100	?	10 years ±30 months	-18.1	10.2	3.2	42.4	14.9	5.0
#12	049	74	?	10 years ±30 months	-18.6	9.6	3.3	41.7	14.8	2.0
Adult female mean=9.5 ± 0.4										
Stylos										
#8	012	1(1990)	?	Fetus	-19.2	10.1	3.49	39.3	13.1	2.0
#9	013	1(1990)	?	Newborn	-18.3	9.3	3.19	26.4	9.7	3.0
#4	008	26a	?	Newborn	-19.4	10.5	3.46	34.8	11.7	2.1
#2	005	16a	?	6.5–7.5 years	-19.7	8.8	3.30	27.4	9.7	3.0
#12	020	24	?	7–8 years	-19.6	10.1	3.44	42.5	14.4	1.3
#3	007	26a	?	7.5–8.5 years	-19.7	9.1	3.34	43.1	15.0	1.8
#7	011	1(1990)	?	7.5–8.5 years	-19.5	9.1	3.39	27.6	9.5	1.4
#10	014	1(1990)	?	7.5–8.5 years	-18.8	9.7	3.32	44.3	15.6	4.0
Adult female mean=8.8 ± 1.2										

Table 4.7 Non-adult $\delta^{15}N$ values and adult female mean for Nemea, Petras and Servia

Age at death	$\delta^{15}N$ (‰)
Nemea	
16–32 months	8.6
5–10 years	7.5
Adult female mean=8.5 ± 1.0	
Petras	
30–42 months	12.7
4–5 years	8.6
5.5–6.5 years	9.6
6–7 years	8.9
Adult female mean=9.2 ± 0.3	
Servia	
c. 12 months	11.3
3–7 years	9.5
8–11 years	9.2
Adult female mean=8.5 ± 0.3	

Adapted after Bourbou and Garvie-Lok 2009, table 1

*Figu*re 4.9 presents the data for the eight sites in this format. A $\delta^{15}N$ elevation is seen in the youngest individuals. Many of the non-adults aged 3 years or less at death show a substantial elevation (2‰ to 4‰) over the mean adult female value at the same site. This result is consistent with the protracted period of breastfeeding described in documentary sources reviewed above. In contrast to the general elevation seen in the youngest individuals, non-adults aged 4 years or older at death are scattered within 1‰ of the adult female mean, reflecting an essentially adult diet. The ±1‰ fluctuation in $\delta^{15}N$ around the adult female mean for these older non-adults reflects normal individual variation within each population, and is seen in adults from these sites as well. Exceptions to this are two children aged approximately 6 years from Eleutherna (skeletons 016a and 020g) that have enriched ^{15}N values, which could be a result of prolonged breastfeeding or nutritional stress.[118]

The data available from this study do not allow firm conclusions to be drawn about weaning behavior in Byzantine Greece. However, they allow us to make some tentative suggestions, and to point to directions for further research. The contrast between the elevated values seen in non-adults aged 3 years or less and the adult-like pattern seen in children aged 4 and older suggests that weaning was

118 Fuller et al. 2005.

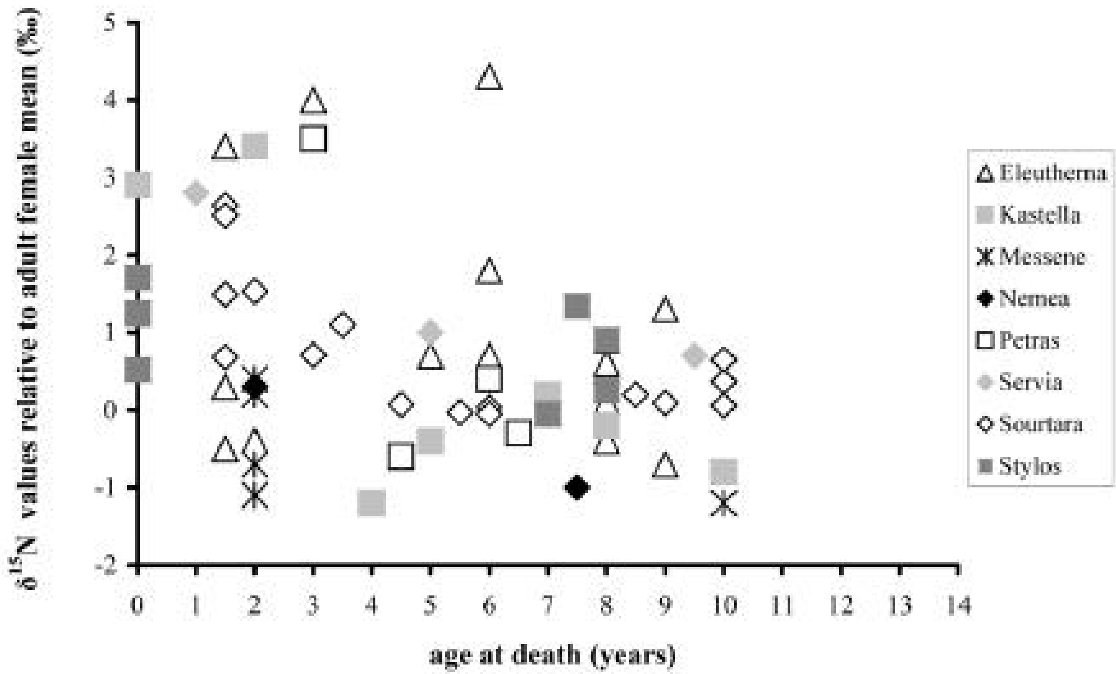

Figure 4.9 $\delta^{15}N$ non-adult values and adult female mean

complete by the fourth year. This suggestion is consistent with the documentary evidence, with the exception of the description in the Vita of Basil the Younger, and it is probably safe to conclude that the description in that Vita does not indicate that children would normally have been nursed into the fourth year.

Arriving at a more precise age of weaning than 'before 4 years of age' is not possible given the data available. Many of the non-adults aged 3 years or less at death show a substantial $\delta^{15}N$ elevation above the adult female mean for their site, suggesting that mother's milk had formed a significant portion of their diet. Due to the lag between a change in diet and a shift in bone $\delta^{15}N$ values, this result does not necessarily suggest significant nursing up to the age of 3, but does indicate that breastmilk formed a substantial part of some infants' diets well into the third year of life.

Bourbou and Garvie-Lok have also discussed the isotopic data derived from a number of Roman and late medieval sites.[119] Isotopic data for Roman populations from Isola Sacra near Rome (first to third centuries AD),[120] the Dakhleh oasis of Egypt (c. AD 250-450)[121] and Queenford Farm in Britain (late fourth to mid-sixth centuries AD)[122] are also consistent with late weaning ages. Despite wide geographic separation of these populations and presumed local cultural differences, the three studies suggest a similar weaning pattern, with some individuals nursing to the age of 3 years. Fuller and colleagues[123] have pointed out a contrast between this apparent Roman weaning pattern and that seen at the medieval British site of Wharram Percy (tenth to sixteenth centuries AD),[124] where stable isotope values suggest that children were weaned at an earlier age – between 18 months and 2 years. According to Fuller and colleagues, this contrast could reflect a stronger influence by the physician Soranus and other medical scholars among the earlier Roman populations, who appear to have followed the physicians' advice for a gradual weaning process, while later medieval populations chose to wean their children at a younger age. The Greek Byzantine data are notably consistent with the later weaning ages found among these Roman populations. Further and more extensive studies on Byzantine populations would provide additional evidence to determine whether a difference in weaning practices existed between Byzantine and medieval western European populations – with Byzantine groups having maintained traditions carried over from the Roman period.

119 Bourbou and Garvie-Lok 2009.
120 Prowse et al. 2004.
121 Dupras, Schwarcz and Fairgrieve 2001.
122 Fuller et al. 2006b.
123 Fuller et al. 2006b.
124 Richards, Mays and Fuller 2002.

The particular choice of honey and goat's milk in infant feeding, documented in the written sources, could have had serious adverse consequences on infant health.[125] Honey is often contaminated with the spores of *Clostridium botulinum*, the bacterium that secretes the toxin that causes botulism, a severe and often fatal form of food poisoning.[126] Botulinum toxin blocks the transmission of chemical signals at neuromuscular junctions; left untreated it can cause death through paralysis of the muscles of respiration.[127] In the infant, *C. botulinum* spores can colonize the intestinal tract, leading to infant botulism, an illness of varying severity whose symptoms include reduced muscle tone, difficulty suckling and sometimes respiratory problems.[128] In modern populations, most infants who develop infant botulism recover after an illness lasting several weeks or several months; in antiquity, however, recovery may have been less certain. The use of goat's milk as a dietary staple for infants can also result in serious complications. Although goat's milk is popularly seen as similar to human milk, it is relatively low in both cobalamine and folic acid (0.1µg/l and 6 µg/l, respectively) compared to human milk (4µg/l and 52 µg/l, respectively). Infants who are fed goat's milk rather than human milk starting shortly after birth develop severe megaloblastic anemia by the age of about 3 to 5 months due to folic acid deficiency.[129] In some cases these health consequences would be visible in the osteological record. For example, the occurrence of active cribra orbitalia (see Figure 3.5 in Chapter 3) in an infant younger than 6 months suggests that the diet of the child was likely based on or supplemented with goat's milk.[130]

Weaning represents a crucial period in a child's life. The type of food introduced after cessation of breastfeeding, as well as cultural factors that influence weaning practices, can be related to the development of specific pathological conditions, and offer a plausible explanation for the clustering of deaths around the weaning age in non-adult mortality patterns. The bioarchaeological and isotopic analysis of larger non-adult samples is expected to further contribute to a better understanding of the cultural and environmental conditions in which feeding

125 Fairgrieve and Molto 2000.

126 Nevas et al. 2005.

127 Passmore and Eastwood 1986.

128 Arnon et al. 1979; Merenstein, Kaplan and Rosenberg 1991; Shapiro, Hatheway and Swerdlow 1998.

129 For a thorough discussion of the recommended folic acid intake and its implications, see Chanarin 1990.

130 Fairgrieve and Molto 2000 have argued that in the Roman Mediterranean, where goat's milk is known to have been given to infants, the development of this condition in such young individuals may reflect folic acid deficiency caused by a diet based on goat's milk.

practices take place, and of how these practices can enhance the maintenance of balanced health or expose a child to the risk of death.

Conclusions: Reconstructing Health and Disease Patterns in Byzantine Crete: Results and Perspectives

The investigation of daily life and living conditions in the Byzantine world is a relatively underexplored subject, taking a back seat to more visible aspects of Byzantine culture such as works of art and ecclesiastical architecture. The aim of this book has been to provide an overview of health and disease in Byzantine Crete that includes all available bioarchaeological data. Given the limited number of collections of Byzantine skeletal material that have been excavated, curated and published, a substantial quantity of evidence has been considered in this book: the evaluation of published and unpublished data compiled between 1976 and 2009 and generated by various researchers, including the author, has drawn on the evidence of 445 skeletons from six sites.

A first step in the composition of this study was the contextualization of the biological data, since neglect of the cultural context would have provided only a shallow glimpse into past human life, representing individuals as isolated vessels of suffering or healthy bodies. The combining of these pieces has created a basic framework for the study of the populations, focusing on specific aspects of Byzantine life that could contribute to the discussion of the biological data and the reconstruction of health and disease patterns. For example, natural disasters, daily hazards and conditions of sanitation are significant pieces of a larger picture that affords a better understanding of the development and buffering of various pathological conditions and the formation of mortality patterns. Examination of the qualitatively diverse biological data has produced a strong body of raw data that could facilitate future comparative studies. To this end, discussion of the biological findings includes citation of the applied methodology, definitions and diagnostic criteria for the observed pathological conditions, and photographic and radiographic aids. For the benefit of paleopathological research, estimates are provided of both the number of individuals affected by a pathological condition (crude prevalence rate) and the number of skeletal elements affected (true prevalence rate), and these are presented also in detailed tables and associated graphs.

The paleopathological basis of the present study has brought new evidence to the reconstruction of living conditions in Byzantine Crete. Through the analysis and interpretation of the mortality profiles, of the observed pathological conditions and of the data retrieved from the application of chemical analysis, the study of human remains of the populations of Byzantine Crete has offered possible answers to questions about health and disease patterns and dietary habits.

In the broadly agriculturally and pastorally based economy of Byzantine Crete, people would have been engaged in activities that contributed primarily to the household economy and to the maintenance of the most important unit of society, that of the family. For males, who by nature have a less effective immune response than females, the daily hazards encountered during the performance of demanding and hard-labor activities exposed them to the risk of temporary or permanent disability, and even to death. Females, on the other hand, were especially at risk from complications associated with pregnancy and childbirth. These conditions have enabled us to account for a clustering of deaths in the most productive age categories (from 15 to 34 years) and in some cases, where conditions were even less favorable, to account for the high number of deaths (for example, in the case of Eleutherna, where almost one-third of the population died within this age range).

The populations under study experienced a wide range of pathological conditions, which have provided valuable clues about their overall health status. Some of these conditions did not affect the normal functioning of the afflicted individual during life: these include, for example, spina bifida occulta, which even today is discovered only in the course of routine radiological examination, and button osteoma, which is one of the most common benign bone neoplasms encountered in both archaeological and modern populations. Other pathological conditions, however, prohibited their possessors from functioning satisfactorily. Such was perhaps the case of the 19-year-old individual with humerus varus, who most likely lived with a slightly disabled shoulder and arm.

The data presented here on dental, degenerative and infectious diseases, hematopoietic disorders and traumatic incidents, namely fractures, have offered an insight into the complex interaction between cultural and environmental factors, particularly in the areas of diet and subsistence, strenuous living conditions and daily hazards. Dental diseases were among the most frequently observed pathological conditions, affecting primarily middle-aged adults and male individuals. Cleaning of the teeth does not seem to have been a customary practice in the studied populations, and the types of foods that were consumed largely determined the development of specific dental diseases. Calculus, for example, the second most frequently observed pathological condition in the sample, is indicative of a more protein-rich diet, as it usually develops in the mouth in an alkaline environment.

The presence of osteoarthritis in major joints and in the vertebral column in the populations studied here has been associated with the wear and tear occasioned by everyday activities; that is, although osteoarthritis is a multifactorial condition, the primary contributing factors were determined to be age and mechanical stress. The skeletal data on degenerative joint disease demonstrates that males, particularly of younger age groups, suffered more than females. Although these sex differences in the data may be related to factors such as hormones, body size and anatomy, rather than to activity, the observed pattern may be suggestive of a more demanding lifestyle for male individuals, for whom an early onset of work could be also suspected. Schmorl's nodes, in particular, can occur idiopathically or can be associated with specific pathological conditions, but their development is most commonly the result of degenerative changes associated with ordinary stress on the vertebral column. On the basis of recent clinical studies that document a relationship between Schmorl's nodes and pain, these lesions can be expected to have adversely affected the quality of life of the populations.

For years now porotic hyperostosis and cribra orbitalia have become almost synonymous with iron-deficiency anemia in the bioarchaeological literature, and their diagnosis has been highly influenced – especially for Greek skeletal populations – by Angel's hypothesis that they reflect thalassemia genotypes as a response to endemic malaria. But multifactorial etiology is probably the most appropriate model for interpreting the causative mechanisms responsible for the development of these lesions. In the populations studied here, it is suggested that a combination of factors, including a vitamin B12-deficient diet, could account for the prevalence of porotic hyperostosis and cribra orbitalia at some sites.

Diagnoses of infectious conditions in the sample were limited to the presence of periosteal reactions, mainly on the long bones of the lower limbs (tibia and fibula), and to a possible case of actinomycosis. As actinomycosis is a chronic granulomatous, suppurative disease of humans and cattle, it could be indicative of close contact with domesticated animals, which favors the development of poor sanitary conditions. Periosteal lesions, if not of systemic hematogenous origin, could represent a bony reaction to overlying skin trauma caused by everyday activities. The predilection of male individuals to these lesions may reflect greater exposure to repeated minor trauma to their lower limbs, possibly as a consequence of gender influences on occupations.

Fractures reported in the sample reflect a lifetime of encounters with the environment and fellow humans. Middle-aged and mature males sustained the majority of the observed fractures, primarily as a consequence of falls caused by the individual's own clumsiness or accidental injuries during the performance of everyday activities. Multiple fractures on the same individual, although possibly suggestive of an exceptionally dangerous life marked by repeated traumatic events, seem unlikely to be the result of constant physical abuse, since they did not present different stages of healing. The possibility of injuries due to interpersonal violence could be suspected for the observed cranial injuries (one of them resulting in the death of the individual) and for the observed scapular fracture. None of the recorded fractures could be attributed to an underlying disease, and although complications were noted in a number of them, such as osteoarthritis or loss of the normal shape of the bone, all of the observed fractures demonstrated healing process – a clear indication that the individual survived the incident. It is suspected that the impact of each fracture played a significant role in the performance of daily activities, which could have been particularly evident if the individual was involved in manual labor. A farmer, for example, would have been less successful in performing many farming activities, due to pain, weakness and reduced range of motion.

Childhood – the most sensitive stage of the human life cycle – has merited special attention in the analysis. The study of the biological and social profile of Byzantine children highlights numerous aspects of their precarious lives, allowing a more detailed reconstruction of what it was like to be a child in Byzantine society. The investigation of non-adult mortality patterns informs us about the cultural and biological circumstances experienced by this age group, providing a reliable marker of the group's adaptability to the cultural and natural environment, and a valuable testament to the ability of the adult population to maintain good health in the most vulnerable members of the society. At those sites considered in the present study where child mortality exceeded infant mortality, as for example in Eleutherna, causes have been sought within the conditions of poor sanitation and among cultural factors that influenced weaning patterns. The presence of specific pathological conditions, such as scurvy, suggests that weaning stress played a significant role in the construction of the non-adult mortality profile.

Food, essential for the survival and maintenance of a healthy organism, has been taken up in the final chapter. The investigation of written sources, supplemented by evidence retrieved from chemical analysis, has provided a picture of Byzantine dietary habits. Documentary evidence portrays a Byzantine diet based on grain (primarily wheat and barley), oil and wine, supplemented with legumes, dairy products, meat and marine resources, but the relative importance of each foodstuff in the Byzantine diet is not always as clear.

The application of stable isotope analysis on nine Byzantine populations throughout Greece has provided new information on their dietary habits. The derived $\delta^{13}C$ and $\delta^{15}N$ values are quite tightly clustered, suggesting that all of these populations may have eaten a broadly similar diet. Carbonate $\delta^{13}C$ values, which indicate that most calories came from C_3 plants or C_3-feeding animals, are consistent with a diet based on the 'Mediterranean trinity' of wheat, oil and wine. Although substantial dependence on a C_4 grain staple, such as millet, was not indicated at any of the sites, at the inland site of Sourtara a range of 2‰ in $\delta^{13}C$ values and little change in the $\delta^{15}N$ values suggests that the population consumed some domesticated animals that had a C_4 component in their diet. Collagen $\delta^{13}C$ values are in the range usually associated with C_3 terrestrial resources, while $\delta^{15}N$ values are high relative to those of domesticated animals from Byzantine sites. The isotopic data do not support hypotheses of a general dependence on low-$\delta^{15}N$ legumes, since substantial legume consumption is inconsistent with the high collagen $\delta^{15}N$ values seen for all sites. Instead, the values suggest that significant amounts of animal protein were included in the Byzantine diet.

One unanticipated pattern offered by the stable isotope analysis is the increase in marine protein consumption, seen at the coastal sites (a reasonable expectation given their location) but also evident for some individuals at the inland sites. This pattern contrasts with previous isotopic studies on prehistoric populations, which have suggested that among coastal populations marine species contributed little if at all to the diet. Does the pattern indicate that the Byzantines were well aware that fish and most of the aquatic animals provided high nutritional value and that they had further developed specific fishing methods for the various species? Did fasting rules, where fish consumption is allowed for a considerable time throughout the year, contribute to the increased consumption of fish and aquatic species? For inland sites, the isotopic values may be indicative of a high consumption of dairy products (known from the written sources to have been generally available across classes and regions), but another possibility is that freshwater fishes (also attested in the written sources) were consumed in areas where lakes and rivers existed. Whatever the cause, the stable isotope data are broadly suggestive of inland and coastal Byzantine populations supplementing an essentially land-based C_3 diet with some possible C_4 and marine resources.

Isotopic studies conducted to date also offer insight into the diet of the very young, suggesting that Byzantine children were weaned at a relatively late age. The data available from this study affords no firm conclusions about weaning behavior in Byzantine Greece. They have allowed us, though, to make some tentative suggestions and to recommend directions for further research. The contrast between the elevated values seen in non-adults aged 3 years or less and the adult-like pattern seen in children aged 4 and older suggests that weaning was completed by the fourth year – a pattern consistent with data derived from the written sources. The study of documentary evidence on infant feeding, attesting, for example, the use of honey and goats' milk, and current clinical data have offered additional information on serious health problems, such as botulism and megaloblastic anemia, that could have resulted from the type and nutritional quality of the food introduced.

This book provides an assessment of the trends suggested by the available datasets within the biocultural context of Byzantine Crete: people experienced demanding lifestyles, where hard work was the norm both for indoor and outdoor activities; were prone to accidents – and even to violent attacks; and in some cases lived on poor diets. It is hoped that this work will also point the way for the future, encouraging the use of biological data in the tracing of past populations' health and contributing to interdisciplinary cooperation. Although this study has not exhausted the wealth of information attested in the written sources or in the archaeological record, it highlights the need for close collaboration among physical anthropologists, historians and archaeologists, since the interaction of biological and cultural data is fundamental when working with historic populations. The study of disease is an interdisciplinary task and those involved in the analysis of human skeletal remains will be better informed through familiarity with current anthropological and archaeological research agendas on a regional, national and international level. The development of a continuous and healthy dialogue between physical anthropology and archaeology will ensure that biological and cultural issues can be addressed.

Success in this collaboration will require changes in the way that physical anthropology is viewed within the field of archaeology. Most of the archaeological and anthropological work in Greece is subject to the vagaries of poorly funded projects: people working within tight budgets and on short time schedules, where post-excavation study, especially of human remains, is not always possible. Skeletons retrieved in an excavation have no less scientific value than artifacts and architectural remains. Although the latter usually monopolize the interest of researchers, the study of both the products and the producers contribute to a better reconstruction of life in the past. Human collections from historic times, including those of Byzantine Crete, are by no means less important than prehistoric ones, as historic populations offer a great advantage: the solid background of documentary evidence against which the biological data can be projected.

A hope of the author is that this book will be useful in its immediate intent, serving as a resource from which subsequent studies can extract valuable information or tackle bigger questions. For the future, an improved standardization of the methodology used in the recording, analysis, integration, interpretation and publication of data should be more easily achieved if it starts from the baseline set by current bioarchaeological studies in Greece.

Glossary

Actinomycosis: A chronic granulomatous disease of humans and cattle, that may be systemic or localized, caused by the bacterium *Actinomyces israelii* from within the oral cavity. Actinomycosis presents in three different forms depending on the location of the lesion: head/neck, abdomen and chest/lungs.

Ankylosis spondylitis: A seronegative joint disease, characterized by inflammation of the synovial joints and involvement of the tendon insertion points of bones. It usually affects the sacro-iliac joints first and then moves up the spine, which can become fused, and erosive lesions may be visible on the vertebral bodies. Spinal ligaments become inflamed and may ossify, thus fusing the spine into a characteristic "bamboo" appearance and causing decreased mobility. The condition affects males more frequently than females. Its specific cause is unknown; most people, however, have the HLA B27 antigen in their blood.

Annulus fibrosus: The tough fibrous outer zone of the intervertebral disc that normally retains the soft inner nucleus pulposus.

Appendicular: Relating to the appendages of the skeleton, namely the upper and lower limbs (arms and legs).

Botulism: A severe, often fatal form of food poisoning caused by the saprophyte *Clostridium botulinum*.

Callus: A composite mass of tissue formed at the site of a broken bone; it is composed initially of uncalcified fibrous tissue and cartilage and ultimately of bone.

Cartilage: Gristle; chondrus – a connective tissue characterized by its nonvascularity and firm consistency.

Cloaca: Cavity (pus-containing abscess) from within the bone interior.

Collagen: An important protein structural element of the body.

Colles' fracture: The distal end of the radius is broken and the fragment displaced posteriorly.

Costochondral: Relating to or joining a rib and costal cartilage.

Cribra orbitalia: The presence of many small holes on the orbital roofs.

Dental attrition: Wear on the biting surfaces of the teeth caused by normal use.

Diploic (diploë): The spongy layer of bone between the hard outer and inner layers of the flat cranial bones.

Distal: On the dental arch a location further from the median line of the jaw; on a long bone the lower end (the end farthest away from the mid-line of the body).

DNA: Abbreviation for deoxyribonucleic acid, the very long molecule that winds up to form a chromosome and that contains the complete code for the automatic construction of the body.

Eburnation: Bone sclerosis; polished joint surface that develops when a joint continues to be used after the cartilage protecting it has been destroyed.

Enamel hypoplasias: Defects on the enamel surface of the teeth in the form of horizontal lines, pits or grooves, usually more easily seen on the cheek surfaces of the incisors and canines. These defects occur only while the teeth are developing and remain as a permanent record in adulthood. Among the possible causes of enamel hypoplasias are nutritional deficiencies, fever and childhood illnesses such as measles.

Epiphysis: End part of the shaft of a long bone.

Fibrocartilage: A tough form of cartilage containing many thick bundles of collagen fibers.

Folic acid: A vitamin of the B group necessary for the synthesis of DNA and red blood cells.

Granuloma: A collection of inflammatory cells representing a chronic inflammatory process.

Hamartoma: A focal malformation that resembles a neoplasm, grossly and even microscopically, but results from faulty development in an organ.

Harris lines: Transverse lines of radiodensity at the ends of long bones. They are considered a popular indicator of physiological stress (for example, influenza, measles, surgery, starvation, vitamin deficiency, emotional stress etc.) in ancient populations, but are problematic on account of interpretation of their etiology and limitations associated with the recording of these features. Only about one-fourth of these lines in non-adults persist into adulthood.

Humerus varus: Slipped proximal epiphysis of the humerus.

Hypervitaminosis A: Excess intake of vitamin A. The condition manifests itself in diffuse periosteal reaction no earlier than the end of the first year of life.

Hypoplasias: See enamel hypoplasias.

Idiopathic: Adjective used in characterizing a disease of unknown cause.

Infantile cortical hyperostosis (or Caffey's disease): The condition affects infants in the first six months of life and is characterized by massive deposition of layered periosteal woven bone on one or more bones. Its etiology is unknown; a viral infection is suggested.

Inflammatory (inflammation): The response of living tissue to injury, featuring widening of blood vessels, with redness, heat, swelling and pain.

Intervertebral disc: A disc-shaped, fibrocartilaginous, shock-absorbing structure lying between the bodies of adjoining vertebrae in the spinal column. Each disc consists of an outer fibrous ring (annulus fibrosus) and an inner soft core (nucleus pulposus).

Kyphosis: Deformity of the spine characterized by extensive flexion.

Lamellar bone: New bone formation in a disease process; more mature, older, organized in appearance. Lamellar bone may indicate that the process was quiescent or had been overcome.

Lytic (lysis): Destruction or dissolution.

Megaloblastic anemia: Anemia characterized by high numbers of abnormally large, nucleated red blood cells, precursor cells in the bone marrow and in the blood.

Neoplasm: A new and abnormal growth of tissue that serves no function and develops at the expense of the healthy organism.

Nucleus pulposus: The pulpy (soft, spongy) core of the intervertebral disc that is surrounded by annulus fibrosus.

Osteoarthritis (OA): Degenerative disease of the synovial joints.

Osteochondritis dissecans: A form of aseptic necrosis of the epiphysis in which a fragment of cartilage and/or subchondral bone becomes detached.

Osteophyte: A bony outgrowth or protuberance.

Osteoporosis: A form of bone atrophy involving both the collagen scaffolding and mineralization; it is commonest in females after the menopause.

Parry fracture: The distal end of the ulna is broken; may indicate interpersonal violence (defense against a blow to the head by raising the forearm).

Periosteum: The thick fibrous membrane covering the entire surface of a bone except its articular cartilage.

Periostitis: Inflammation of the periosteum as a reaction to trauma or the result of certain pathological processes.

Porotic hyperostosis: Small holes on the external surface of the skull, particularly on the parietal and occipital bones.

Rickets: A metabolic disorder caused by vitamin D deficiency.

Sacralization: Fusion of the fifth lumbar vertebra with the first sacral vertebra.

Schmorl's nodes: Depression on the surface of the vertebral body, produced by the pressure introduced by the intervertebral disc.

Scoliosis: Lateral curvature of the spine.

Scurvy: A metabolic disorder caused by vitamin C deficiency.

Spina bifida occulta: A defect of the bony spinal canal usually occurring in the sacrum without protrusion of the spinal cord.

Spondylosis: Degeneration of the vertebral bodies.

Subchondral: Beneath or below the cartilage.

Sudden Infant Death Syndrome (SIDS): The sudden death of any young infant or young child, unexpected by earlier medical history, and in which a thorough postmortem examination fails to demonstrate adequate cause of death.

Subperiosteal: Under the periosteum.

Synovial joint: A mobile joint (for example, the knee joint).

Thalassemia: One of several hereditary abnormalities affecting the synthesis of globin chains of hemoglobin leading to severe anemia. It is common in the regions surrounding the Mediterranean basin.

Woven bone: New bone formation in a disease process that is immature or primary and whose appearance is porous and disorganized. Woven bone indicates that the disease process was active at the time of death.

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